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HEVEA BRASILIENSIS

OR

Para Rubber,

ITS BOTANY, CULTIVATION, CHEMISTRY
AND DISEASES.

HERBERT WRIGHT.

THIRD EDITION.

COLOMBO:

A. M. & J. FERGUSON.

LONDON:

HAULAHEN & SONS

1908.

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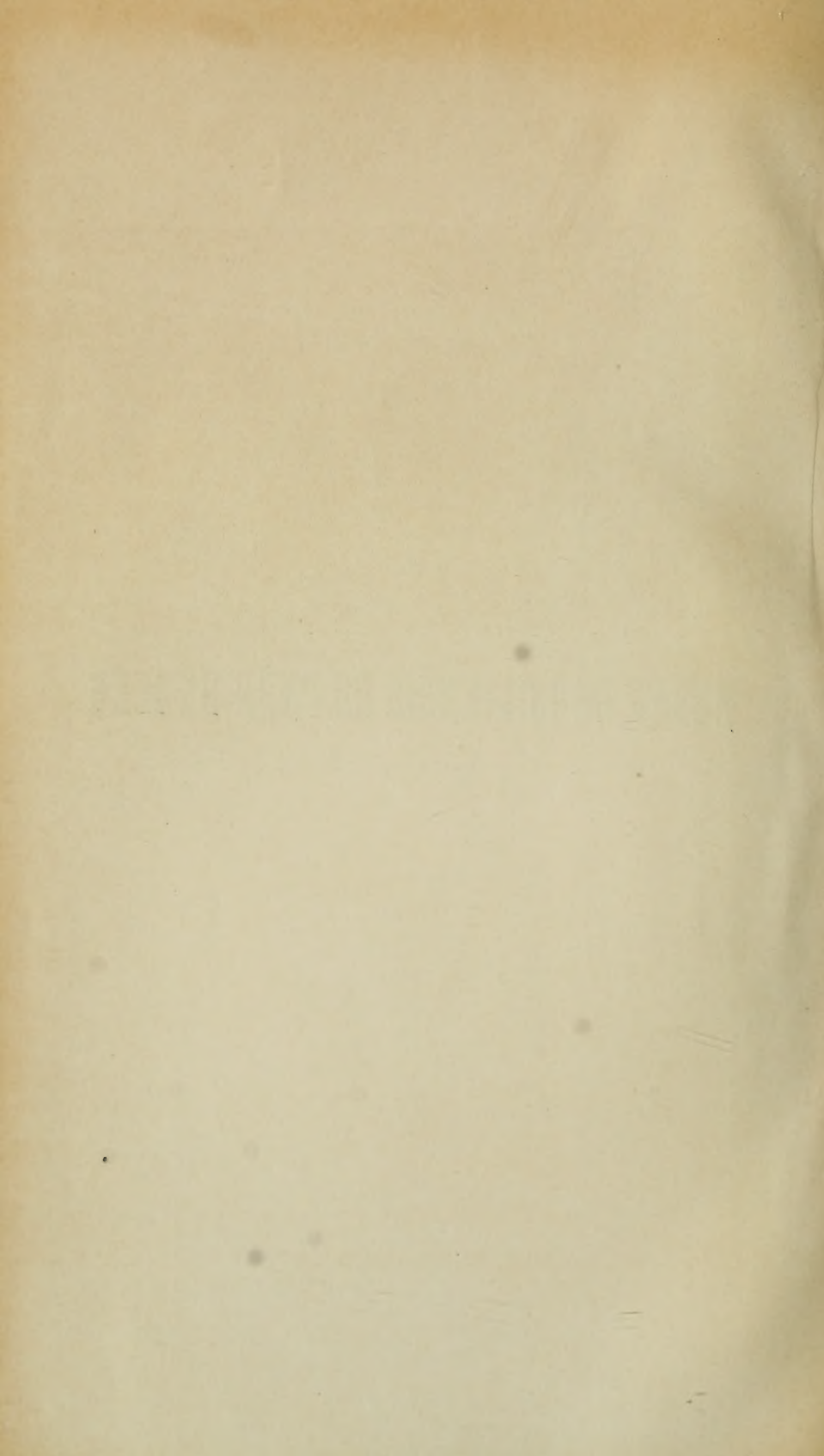
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HEVEA BRASILIENSIS OR PARA RUBBER.





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PARA RUBBER TREES (*HEVEA BRASILIENSIS*) IN CEYLON.

A PLANTATION IN THE HENARATGODA BOTANIC GARDENS.

HEVEA BRASILIENSIS

OR

PARA RUBBER

ITS BOTANY, CULTIVATION, CHEMISTRY AND
DISEASES

BY

HERBERT WRIGHT, A.R.C.S., F.L.S.,

Late Controller, Government Experiment Station, Peradeniya, Ceylon;

Editor, The India-Rubber Journal;

*and Author of "Rubber Cultivation in the British Empire," "Science of Para
Rubber Cultivation," "Theobroma Cacao," etc.*

THIRD EDITION.

WITH PLATES AND DIAGRAMS.

COLOMBO :

MESSRS. A. M. & J. FERGUSON.

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A. M. & J. FERGUSON,
PRINTERS AND PUBLISHERS.
COLOMBO.

PREFACE TO THE THIRD EDITION.

I am writing these notes while enjoying a tour through Ceylon, Malaya, Java, and Sumatra under conditions which might lead the average man to go into some little detail regarding rubber trees and their cultivation in the East. But the size of this book has already greatly exceeded the dimensions originally anticipated and I do not therefore propose to write anything beyond an explanation of why this edition is being printed.

The first practical work on Rubber cultivation for Planters in the East was compiled by the Hon. Mr. John Ferguson, C.M.G., in 1883. Some 700 to 800 Planters read that work and not a few planted rubber; with what wisdom and foresight recent events have shown. In 1905, while I was Acting Director of the Peradeniya Department, Mr. Ferguson suggested that I should write a book on "Para Rubber"; an application was duly forwarded to Government and their permission to compile and publish the book was granted.

In the previous edition, written long before the Ceylon Rubber Exhibition, I pointed out that the industry, as far as growers were concerned, was in its infancy. The present edition has been compiled in consequence of the many advances which have been recently made in methods of cultivation and tapping, coagulating, and curing operations. I have, since I retired from the Ceylon Service, had signal opportunities of studying the rubber industry from many points of view; the wider knowledge thus gained prompted me to give a more detailed account of essential operations as carried out by rubber collectors in all parts of the world.

I again express my gratitude to Planters and Officials in the tropics, to manufacturers in Europe, and to the proprietors of the "India-Rubber Journal", for the information which they have kindly placed at my disposal. Without their assistance the present compilation could not have been published.

H. W.

May, 1908.

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PARA RUBBER SEEDLINGS IN NURSERY.

CHAPTER I.

HISTORY OF PARA RUBBER IN THE EAST.

Work of Wickham, Chapman and Cross—Illustration showing old trees—Propagation from cuttings from two- to three-year-old trees—Flowering for the first time in Ceylon and the Straits—First seed in Ceylon and the Straits—Distribution of seeds and plants from Ceylon—Cultivation—Yields—Preparation—Value—Export—and Acreage of Para rubber in Ceylon from 1884 to 1908—Distribution of Ceylon rubber—Acreage in Malaya, Ceylon, Sumatra, Java, and India—Acreage in all parts of Ceylon during 1906—Para rubber in Kalutara—Para rubber in India—Rubber in Federated Malay States, Straits Settlements and Johore—Carruthers' estimate of area planted in rubber in Malaya in December, 1907—Para rubber planted in British Borneo—Para rubber cultivation in Java—Para rubber cultivation in Sumatra—Para rubber in Samoa.

HISTORY OF INTRODUCTION TO CEYLON AND THE EAST.

THOUGH rubber had been known for many years it was not until 1875 that the now famous Para rubber was seriously talked about in Ceylon. In the following year nearly two thousand seedlings of *Hevea brasiliensis* were despatched to Peradeniya, Ceylon, from Kew. These were contained in Wardian cases and arrived by the ss. "Duke of Devonshire" in excellent condition, under the care of Mr. W. Chapman. They were raised from seeds collected by Mr. Wickham who succeeded in securing 70,000 in the Ciringals of the Rio Tapajos

Mr. Cross was also sent to South America to bring home plants in case the transmission of living seed should prove impossible. He arrived at Kew in November, 1876, and brought with him about 1,080 seedlings without soil, of which, with the greatest care, scarcely three per cent. were saved; from these, about 100 plants were propagated at Kew and subsequently sent to Ceylon. A photograph of a Para rubber plantation at Henaratgoda with trees 15 to 20 years of age is shown elsewhere. The cost of procuring the seeds and plants, including freight and other expenses, appears to have been no less than £1,505 4s. 2d., or an equivalent of about Rs. 11 for every

plant delivered in Ceylon. The whole expenditure was borne by the Indian Government. Burma, Java, Singapore, and the West Indies also received small consignments from Kew direct in 1876.

PROPAGATION FROM CUTTING AND THE FIRST SEEDS IN THE EAST.

The plants were first propagated from cuttings, the twigs from two to three-year-old trees being used for this purpose, and a consignment of 500 rooted plants was sent, from Ceylon, to British Burma and Madras in 1878. But as far back as 1873 a parcel of 6 plants was sent from Kew to Calcutta, and another batch of 50 plants was also despatched from the same source in 1877. Burma obtained about 50 plants direct from Kew in 1877.

The plants at Henaratgoda, Ceylon, flowered for the first time in 1881, when they were five years old. The plants at Peradeniya did not flower until a few years later—1884—but curiously enough, at Perak the small trees only 35 feet high and 2½ years old flowered in 1880.

The trees at Peradeniya did not flower in 1882, and only 36 seeds were secured in that year at Henaratgoda. Mr. Low sent, from the Experimental Garden at Perak, eighteen seeds to Peradeniya, but on their arrival they were found to be dead.

In 1883 no less than nine trees flowered at Henaratgoda in March, and the fruit ripened in August. From this crop 260 seedlings were raised, many of which were sent to planters in Ceylon. In 1884 a good crop of seed was produced at Henaratgoda, and over 1,000 seedlings were raised and distributed to officials in suitable parts of the colony. In the same year a few seeds were also produced for the first time at Peradeniya.

DISTRIBUTION OF SEEDS AND PLANTS FROM CEYLON.

After the trees had begun to produce seed the propagation of plants from cuttings was given up. The seed supply from less than 500 trees has risen from 260 in 1883 to about 200,000 at the present time, and every year large quantities of seeds are sent to many tropical countries.

India and the Straits have received a considerable number of Ceylon rubber seeds and plants, the first consignments dating back to 1877 when the cuttings from one-year-old trees were sent from Peradeniya. Mr. H. N. Ridley informs me that the Straits do not appear to have obtained seeds from Ceylon till 1886, when they were

then distributing their own seeds, and he is unable to account for the fate of the material sent from Ceylon at an earlier date. According to Ridley, it is clear from the records of the Botanic Gardens and Murton's reports, that the cuttings from Peradeniya were either not received or were dead on their arrival at Singapore, and in 1879 the Botanic Gardens did not possess any living cuttings or any plants except those brought by Murton and received direct from Kew. Seeds were also sent to Queensland in 1886 and 1889, to Jamaica and Buitenzorg in 1887, to Fiji in 1888, to Borneo and German East Africa in 1891, to Sumatra in 1901, and to the Gold Coast, Seychelles, and Australia during the last few years.

CULTIVATION, YIELDS, PREPARATION, AND VALUE, &c.

When *Hevea brasiliensis* was first introduced to Ceylon it was considered to be most suitable for places little above sea-level, but the good growth obtained at Peradeniya, though less satisfactory than that at Henaratgoda, was sufficient to interest several planters, and consequently seeds were supplied to residents in many parts of the island. At the present time it cannot be doubted that *Hevea brasiliensis* will grow in the Central Province of Ceylon up to 2,000 feet above sea-level and in the Province of Uva at a still higher elevation. This is evidenced by the acreages now under this product in the Peradeniya, Matale, Gampola, Nawalapitiya, Ambegamuwa, Uva, and other districts

Ten or eleven years ago it was thought advisable not to tap trees until they were at least ten years old, and an estimate of $1\frac{1}{2}$ lb. of dry rubber per tree, per year, from the 12th to the 20th year was considered satisfactory. Since that time it has been proved that some trees when four or five years old may yield rubber of marketable value, and in exceptional cases individual trees about eleven years old have given no less than 12 lb. of dry rubber in eight months, and others as much as 25 lb. per tree in twelve months. In the same way steady progress is to be seen in the substitution of paring and spur knives for the carpenter's chisel for tapping operations; in washing machinery for cleansing crude rubber, revolving cylinders for rapidly coagulating rubber, and in the use of chemicals and hot air apparatus for hastening coagulation and curing the product as rapidly and effectively as possible. Simultaneously with general improvements in yield and methods of preparation there has been a steady rise in price to 3s. 6d.-6s. per lb. for some samples of plantation rubber, and a large increase in the acreage under cultivation.

The progress in Ceylon is illustrative of what has taken place in other tropical countries, and the following tables show the range in

PARA RUBBER.

value of Para rubber, export, price per lb., and the approximate acreage in Ceylon from 1884 to 1908 :—

THE RANGE IN VALUE OF PARA RUBBER.

Year.	Annual Export.*	Value.*	Price of some Samples of Plantation Para Rubber.†		Approximate Acreage in Ceylon.‡
			Rs.	c.	
1884	...	nil	..	2 8	—
1885	.. cwt. 11.1.17*	260 0	..	2 5	—
1886	.. 1 package	9 0	..	3 0	—
1887	.. 4 packages	110 0	..	3 2	—
1888	.. 11 „	727 0	..	3 0½	—
1889	.. 14 „	542 0	..	2 9½	—
1890	.. 39 „	1,067 0	..	3 6	300
1891	.. 78 „	2,000 0	..	3 2	350
1892	.. cwt. 65.0. 7	3,325 0	..	2 10	400
1893	.. cwt. 52.2. 0	1,600 0	..	—	450
1894	.. cwt. 82.0. 14	4,400 0	..	2 10½	500
1895	.. cwt. 15.2. 17	1,290 0	..	3 2	550
1896	.. cwt. 157.0. 7	8,760 50	..	3 4½	600
1897	.. cwt. 73.1. 5	7,458 0	..	3 6½	650
1898	.. cwt. 24.3. 20½	3,694 0	..	4 4	750
1899	.. cwt. 70.2. 14	3,838 0	..	—	1,250
1900	.. cwt. 73.1. 19	12,882 75	..	4 0	1,750
1901	.. cwt. 66.0. 0	11,986 0	..	4 1½	2,500
1902	.. cwt. 189.0. 0	38,362 0	..	4 0	4,500
1903	.. cwt. 387.0. 0	84,784 0	..	5 0	7,500
1904	.. cwt. 676.0. 10	221,120 0	..	6 0	11,000
1905	.. cwt. 1,401.0. 0	557,945 0	..	6 to 6-8	40,000
1906	.. cwt. 3,705.0. 0	1,527,539 0	..	6 3	100,000
1907	.. cwt. 7,093.0. 0	2,932,119 0	..	5 8	150,000
1908	.. cwt. 3,052.0. 0	1,023,252 0	..	3 9	165,000

(Up to 30th, April.)

DISTRIBUTION OF CEYLON RUBBER.

The rubber from Ceylon in 1905, 1906 and 1907 was distributed as indicated below :—

Countries to which exported.	Rubber, Quantity.		
	1905. cwt.	1906. cwt.	1907. cwt.
United Kingdom	1,077	2518	4,266
British India	—	119	1
British East Africa	—	—	1
Canada	—	8	—
Australia	8	31	163
Other British Possessions in Asia	—	1	—
Straits Settlements	—	2	—
Belgium	85	55	82
France	22	53	20
Germany	129	124	208
Holland	1	—	3
Italy	—	—	1
United States of America	79	794	2,348
Total	1,401	3,705	7,093

* From the Principal Collector of Customs, Colombo, Ceylon. † Bulletin of Miscellaneous Information, Kew, No. 142, 1898. ‡ From the "Ceylon Directory." § Official figures.

ACREAGE OF PARA RUBBER IN THE EAST

It is very difficult to form a correct estimate of the acreages planted with *Hevea brasiliensis* in the East, but the following table approximately indicates the extent of land under this species :—

Countries.	Acreage Planted			
	1905.	1906-07.	1907-08.	
Ceylon	40,000	100,000	150,000	
Malaya	38,000	90,000	147,300	
Borneo	1,500	3,500	10,500	
Java and Sumatra ...	6,000	20,000	74,000	
India and Burma ...	8,000	20,000	25,000	
	93,500	233,500	406,800	

The Philippines, Fiji, Samoa, New Guinea, and other islands in the East are planting *Hevea brasiliensis*; there will soon be a quarter-million acres of land planted with this species.

ACREAGE OF PARA RUBBER IN CEYLON DURING 1906.

It is difficult to obtain anything approaching a reliable record regarding the acreage planted with Para rubber trees at the present time, but the following table shows* the areas occupied by this product, or about to be planted with it, in a few of the districts in Ceylon :—

		1905.	1907-08			
		Acres.	Rubber Alone Acres.	Rubber & Tea Acres.	Rubber & Cacao Acres.	No. of rubber trees not counted under other headings: Number.
Kalutara	...	13,394	23,574	6,584	—	415,746
Kegalla	...	6,521	7,399	2,203	66	48,500
Pussellawa	...	2,692	415	1,221	—	136,312
Galle	...	2,500	4,995	1,142	—	35,000
Kelani	...	14,000	24,764	13,963	—	689,086
Sabaragamuwa	...	6,200	—	—	—	—
Matale	...	1,898	10,826	3,352	5,692	316,625
Ambegamuwa	...	800	601	504	—	54,976
Kurunegala	...	—	4,519	—	1,366	23,500

In addition to the above there are in the Ratnapura, Passara, Badulla, Kandy, Gampola, Polgahawela, and Dumbura Districts, thousands of acres being planted with Para trees, and there is every reason to believe that similar expansion is taking place in Malaya, India, Java, West Indies, Sumatra, Borneo, tropical America, Africa and other countries. The Ceylon, Indian, and Malayan public companies alone show over 200,000 acres planted, and double that area available and probably suitable for rubber; in addition to these there are large estates in private hands which are rapidly increasing their rubber acreages.

* See Ferguson's Ceylon Handbook and Directory, 1907-08.

PARA RUBBER.

PARA RUBBER IN THE KALUTARA DISTRICT.

In one district of Ceylon alone—Kalutara—there are nearly 20,000 acres under rubber, planted during 1904, 1905, and 1906.

	1906.	1905.	1904.	Previously.	Total.
Rubber only ...	2,457	3,467	1,744	1,232	8,900
Rubber & other products	1,839	1,330	2,234	5,451	10,854
Total. ...	4,296	4,797	3,978	6,683	19,754

PARA RUBBER IN INDIA.

Though Calcutta was the first country to receive plants of *Hevea brasiliensis* from Kew in 1873, the acreage under this species in the whole of India is small when compared with Ceylon and the Federated Malay States. It is impossible to give the area occupied by Para rubber trees alone in India, and the following table, given by Windle at the Ceylon Rubber Exhibition during September, 1906, will show the districts in South India of importance:—

	Acres.
The Nilgiris and S. Wynaad ...	1,200 mostly in coffee (Para chiefly)
Malabar and S. Wynaad ...	400 (Para, Castilloa and Ceara)
Coimbatore ...	1,100 (Para)
Cochin ...	1,000 „
Travancore ...	6,000 „
Shevaroy Hills ...	1,200 (mostly Para in Coffee)
Pulneys ...	100
Mysore ...	—
Coorg ...	2,000 (chiefly Ceara)

Since the above statement was made several companies have commenced operations in the Travancore district and also in Burma, and we may soon expect to see, in Southern India and Burma, about 20,000 to 30,000 acres of planted rubber.

ACREAGE IN MALAYA.

The following tables* show the acreages planted in the Federated Malay States, Straits Settlements, and Johore:

MALAYA.

RUBBER STATISTICS UP TO THE 31ST DECEMBER, 1906.

	F.M.S.	Straits Settlements.	Johore.	Total.
No. of estates ...	242	5	7	254
Total acreage ...	85,579	11,341	2,310	99,230
Opened during 1906, acres	42,154	4,098	1,355	47,607
No. of trees planted up to the 31st December, 1906.	10,745,002	1,987,954	147,800	12,880,756

RUBBER ACREAGE IN THE FEDERATED MALAY STATES.

MALAYA:—In the Federated Malay States a total of 150,000 acres has been reported as alienated for this product. According

* Annual Report, Director of Agriculture, F.M.S., 1906.

to Carruthers, the following was the estimated acreage under rubber for the middle of 1906 in the Federated Malay States:—

Under one year old, 25,000 acres: one year and under two years old, 15,000: under three, 4,500: under four, 4,000: under five, 8,500. The following tables show the extent of land planted with rubber up to the 31st December 1906:—

	Selangor	Perak	Negri Sembilan	Pahang	Total
No. of estates	119	89	25	9	242
Total acreage	44,821	29,612	10,663	483	85,579
Opened during 1906, acres.	19,063	17,678	4,945	468	42,154
No. of trees planted up to the 31st December, 1906.	5,477,390	3,990,462	1,196,150	81,000	10,745,002

The United Planters' Association, however, in their annual report for 1906 state that there are 52,843 acres in cultivation in the Federated Malay States alone, of which 49,033 are under rubber; the low return, as given in the following table may be explained by assuming that several census forms have not been entered and returned:—

Of the census forms returned 69 are from Selangor, 13 from Negri Sembilan, 12 from Perak, and 3 from Pahang.

		Crop Returns (Cwt).		
		Rubber.	1906 actual.	1907 estimated.
Selangor	...	37,712 $\frac{3}{4}$	5,674 $\frac{1}{2}$	9,156
Negri Sembilan	...	8,345	1,594	2,398
Perak	...	4,397 $\frac{3}{4}$	257	717
Pahang	...	163	—	—
Total.		50,618 $\frac{1}{2}$	7,525 $\frac{1}{2}$	12,271

Para.						
	Under 1 year.	Under 2 years.	Under 3 years.	Under 4 years.	Under 5 years.	5 years & over.
Selangor	16,106	5,783 $\frac{1}{2}$	2,968 $\frac{1}{2}$	2,705 $\frac{1}{2}$	1,222 $\frac{1}{2}$	8,080 $\frac{3}{4}$
Negri Sembilan	3,172	1,284	1,283 $\frac{1}{2}$	722	335	1,381
Perak	2,281	947	850	91	61	471
Pahang	163	—	—	—	—	—
Total.	21,722	8,014 $\frac{1}{2}$	5,102	3,521 $\frac{1}{2}$	1,618 $\frac{1}{2}$	9,941 $\frac{3}{4}$

AREA PLANTED IN DECEMBER 1907.

Carruthers has, according to the *Ceylon Observer*, December 19th, 1907, given a detailed estimate of the rubber planted in the Malayan States and has concluded that about 50,000 acres were planted in 1907, making in round numbers 150,000 acres

PARA RUBBER.

with 16,000,000 trees, at 107 trees per acre. The following is his estimate for December, 1907:—

Selangor	...	63,900 acres.
Perak	...	47,300 "
Negri Sembilan	...	15,600 "
Pahang	...	900 "
S. Settlements	...	16,000 "
Johore	...	3,600 "
		147,300 "

PARA RUBBER IN BRITISH NORTH BORNEO.

I am informed by Mr. Cowie, of the British North Borneo Company, that the total acreage of Para rubber planted up to 31st, December, 1907, in British North Borneo, is approximately 3,605 acres, made up as follows:—

The British North Borneo Para Rubber Co.	...	1,027 acres
" Manchester North Borneo Rubber Ltd.	...	515 "
" Langkon North Borneo Rubber Ltd.	...	703 "
" Tenom (Borneo) Rubber Co.	...	500 "
" Sapong Rubber and Tobacco Co.	...	500 "
" Beaufort Borneo Rubber Co.	...	320 "
" North Borneo Trading and Planting Co.	...	500 "

RUBBER IN SUMATRA.

In a recent issue of the "India-Rubber Journal" it was pointed out that Rubber is now grown on 44 estates in Sumatra, and is distributed among the various districts as follows:—

Serdang	...	17 estates.
Langkat	...	7 "
Padang Redagei	...	6 "
Batoe Bahra	...	6 "
Labocan Batol	...	4 "
Asaham	...	2 "
Siah	...	2 "

Fourteen coffee estates are now, on account of the lowered commercial value of that product, planting rubber; rubber and coffee in conjunction take up 19 estates; coffee-coconuts-rubber 2 estates; tobacco-rubber, 4 estates; tapioca-rubber, 2 estates; rubber-coffee-tobacco 1 estate; coffee-rubber-tobacco, 1 estate; coconuts-rubber, 1 estate, and groundnuts-rubber, 1 estate make up the remainder. From enquiry made the *Ceylon Observer* learned that the acreage under rubber cultivation on the East Coast of Sumatra was estimated in December 1907 at 20,800 acres.

PLANTED ACREAGE IN JAVA.

Mr. J. H. de Bussy, of Amsterdam informed the "India-Rubber Journal" that it was difficult to state exactly the amount of land planted in Rubber in Java. On several estates rubber



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RUBBER IN JAVA.

FICUS AND PARA. FICUS ELASTICA 18 MONTHS OLD:

PARA RUBBER 3 YEARS.



Lent by Dr. Tromp de Haas.

YOUNG PARA RUBBER IN JAVA.

EXPERIMENT STATION, BUTENZORG.

STUMPS PLANTED IN JANUARY, 1904, PHOTOGRAPH TAKEN IN DECEMBER, 1905.

planting is done on a small scale, but is, however, continually being extended. The amount of land planted in *Ficus elastica* by the Forest Department of Java was estimated on March 31st, 1906, viz:—13,200 acres; on the same date 1905 at 9,300 acres. During 1905-6, 4,100 acres have been planted.

On March 31st, 1906, there were said to be planted:—

In <i>Hevea brasiliensis</i>	..	585	acres.
„ <i>Castilloa elastica</i>	..	200	„
„ <i>Funtumia elastica</i>	..	8	„

The amount of private land planted in rubber cannot be stated exactly.

The following total estimate on December 31st, 1906, may be considered as a creditable one, viz:—

In Java (Public)	..	20,000	acres.
„ Forest Dept., Java	..	14,000	„

SAMOAN RUBBER DEVELOPMENTS.

Samoa appears to be attracting attention among several Continental firms interested in the cultivation of rubber plants. At the present time there are only two or three very large companies which are concerned exclusively with rubber cultivation, and these are yet in their infancy. There are, however, according to Preuss, several small rubber estates which have existed for a few years. The Samoan people having already secured plants of *Hevea brasiliensis*, *Castilloa elastica*, *Castilloa elastica* variety *Alba*, *Ficus elastica*, *Ficus Rigo*, *Funtumia elastica*, and *Urceola elastica* are now in possession. A fair number of rubber-yielding species of repute are available for experiment and subsequent selection.

In a report on the trade of Samoa for 1906 the Acting Vice-Consul, Mr. T. Trood, gives some particulars of the various rubber planting ventures in that island.

A new British company, the Upolu Rubber Company, Ltd., commenced operations early in 1906, and has already some 200 acres of Para Rubber under cultivation, with cocoa interplanted.

The chief difficulty—that of transport—having been surmounted, it is likely that a great impetus will be given to rubber planting in this country.

A large area adjoining this plantation has recently been cleared by the Safata Samoa Gesellschaft for rubber culture; the Company is also planting rubber through its cacao.

The Berlin Caoutchouc Company is vigorously pushing on its work at Saluafata, 20 miles from Apia, having leased from the natives a tract of land measuring several thousand acres.

From 400 to 500 acres have been planted with cacao, coconuts and rubber by Messrs. Gurr and Moors, the former having 350 acres under cultivation.





Photo by H. F. Macmillan.

THE LEAVES, FLOWERS, FRUITS & SEEDS OF *HEVEA BRASILIENSIS*.

CHAPTER II.

BOTANY OF THE PARA RUBBER TREE.

Characters of the Para rubber tree—Species of *Hevea* and their distribution—Illustration of leaves, flowers, fruits and seeds of *Hevea brasiliensis*—Foliar periodicity of *Hevea brasiliensis* in Ceylon—Fruit periodicity in Singapore—The laticiferous system in various plants—Laticiferous system of *Hevea brasiliensis*—Origin—Distribution and characters—Scott on the origin of the laticifers—Functions of the latex—Observations by Groom, Warming, Parkin, Ridley, Schulerus, Sachs and Haberlandt—Water storing—Prevention against insect pests—Reserve food or excretory—Anatomical details illustrated.

BOTANICAL CHARACTERS OF THE PARA RUBBER TREE.

M. H. Jumelle* devotes considerable attention to the supposed varieties of *Hevea brasiliensis*, and, like many other botanists, concludes that the differences in colour, size, and shape of the leaves described by Ule and others are not constant and may be disregarded. The leaves are trifid, long, and lanceolate.

The flowers are monœcious, and are grouped in panicles of small cymes; each inflorescence has two kinds of flowers, male and female. The calyx is usually five-lobed; the stamens of the male flowers are united in the centre to form a column; the female flowers usually possess five staminodes, a small 3-celled ovary, and 3 sessile or shortly-styled stigmas; the fruit is a three-lobed capsule, in which the three oval oleagineous seeds are contained. The seeds are shiny and speckled brown on the surface.

There are about a dozen species of *Hevea* recognized by Müller, Hemsley, and Huber.

The illustrations herewith given show the characters of the leaves, flowers, fruits, and seeds of *Hevea brasiliensis*.

SPECIES OF HEVEA AND THEIR DISTRIBUTION.

The genus *Hevea* furnishes the largest quantity, and perhaps the best quality, of rubber in the world. It is represented by *Hevea brasiliensis*, Muell. Arg., and *H. similis*, Hensl., in Brazil,

* Les Plantes à Caoutchouc et à Gutta, by Henri Jumelle, Paris, 1903.

Eastern Peru, and Bolivia; by *H. spruceana*, Muell. Arg., *H. minor*, Hemsl., *H. benthamiana*, Muell. Arg., *H. rigidifolia*, Muell. Arg., and *H. discolor* in North Brazil; by *H. pauciflora*, Muell. Arg., in North Brazil and British Guiana; by *H. lutea*, Muell. Arg., in North Brazil and East Peru; by *H. confusa* in British Guiana, and by *H. guianensis*, Aub. In the basin of the Amazon and in the south of Venezuela and the Guianas, species of *Hevea* are abundant and scattered among other forest types; further north they are replaced by *Castilloa* and *Parthenium*, and on the Atlantic side by *Manihot* and *Hancornia*.

Among the species of *Hevea* enumerated above there are several which yield large quantities of latex, but *Hevea brasiliensis* is probably responsible for the greater part of the Para rubber of commerce. *H. benthamiana* has been confused with *Hevea brasiliensis*, and is said to be cultivated, at the present time, in some parts of Venezuela.

H. discolor has lately received considerable attention and though its latex is said to be used for adulterating purposes, it does not appear to possess very much caoutchouc.

Botanically the genus *Hevea* has been divided by Huber ("Ensaio d'uma Synopse das Especies do Genero *Hevea* sob os pontos de vista Systematico e Geographico") into two sections each of which is subdivided into series. *Hevea brasiliensis* belongs to section *Bisiphonia*, Muell. Arg., and series *Intermediae*, and is characterised by having anthers in two complete series, inflorescence pale-yellow or white, buds of the male flowers acuminate, and obsolete styles.

FOLIAR PERIODICITY OF HEVEA BRASILIENSIS.

Trees of *Hevea brasiliensis* exhibit marked foliar and fruit periodicities in the East. After the trees are a few years old they annually pass through a leafless phase; generally, but not always, they show active fruit production during the months of July to October.

In Ceylon the trees usually shed their leaves during the hot season and the following observations apply to some of the oldest trees in the East:—

NUMBER OF TREE AND YEAR.	LEAF-FALL.		NEW LEAVES APPEARED.	NUMBER OF DAYS TREES LEAFLESS.
	Commenced	Finished.		
I. 1901-2. ...	November.	Jan. 6th.	Feb. 2nd.	26 days.
II. 1902. ...	Jan. 1st.	Feb. 28th.	Feb. 23rd.	4 ..
1903. ...	Jan. 3rd.	Feb. 26th.	March 2nd.	3 ..
III. 1903. ...	Sept. 29th.	November.	November.	—
IV. 1902. ...	Jan. 4th.	Jan. 14th.	Jan. 24th.	9 days.
1903. ...	Jan. 21st.	Feb. 3rd.	Feb. 10th.	6 ..



Lent by Macdonald & Sons.

PARA RUBBER TREES SHEDDING LEAVES.
PARA RUBBER LEAVES COVERING SOIL.

FRUIT PERIODICITY IN SINGAPORE.

There is a considerable difference between the trees in the Singapore Botanic Gardens and the average mature trees in Ceylon. In the Straits, according to Ridley, the trees may bear fruit in any month of the year; although the period of heaviest yield is July-October with another heavy yield in the month of March. The following table shows the total number of seeds collected in each month for the past nine years in the Singapore Gardens:—

January	...	32,924	...	July	...	29,650
February	...	55,800	...	August	...	79,600
March	...	148,050	...	September	...	324,515
April	...	56,314	...	October	...	291,436
May	...	28,097	...	November	...	85,870
June	...	28,700	...	December	...	35,807

This agrees more or less with Ceylon, where there is a main or only fruiting period in the Autumn. (The Uva province is the only district in Ceylon where there is a special Spring fruit period, February-April). The best crop month in Spring is March, which over a period of nine years stands third in the annual returns, and varies from nil return in 1905, and only 50 seeds in 1902, to 43,050 seeds in 1901. A similar variation may be observed in the autumn crop for August, which out of a total of 79,600 seeds for 9 completed years produced no less than 60,850 seeds during that month in 1905.

Ridley concludes that (a) while there are two seasons when flowers and fruits may occur in some years within the period of a year, there is never more than one heavy crop; (b) that the autumn crop is the more uniform of the two, as the spring has only exceeded the autumn crop twice in 10 years; and (c) that the autumn fruit periodicity represents the true normal condition of the tree.

THE LATICIFEROUS SYSTEM.

All the species which yield rubber are characterised by systems of sacs, series of cells, or tubes containing latex; these occur in nearly all parts of the plant. The commercial possibilities and the ultimate success of several species are determined by the particular type of laticiferous tissue which each contains. When one considers the great difference in the nature, mode of origin, and development of the laticifers in various plants, there is every reason for suggesting that each species should be tapped on a particular system in order to take advantage of the peculiarities of each type.

From a study of the laticiferous system of our prominent plants, I am convinced that in certain instances the old native and

apparently wasteful methods adopted in the extraction of latex are probably as good as, and even better than, many which have been evolved.

The laticiferous system in several of our important species occurs in the cortex of the stem, branches, roots, and in the leaves, flowers, and fruits. In some species, the laticifers appear to be best developed in the root and the extraction of latex is only considered in relation to that part; in other species there appears to be a better development in the stem, and in a few others the flowers or young twigs show conspicuous developments. Generally, these structures and the latex appear in the embryo and remain until the death of the plant; in some cases, however, the laticifers are not obvious except in plants of some years' growth. Sometimes they are absolutely restricted to stems and roots, the leaves and flowers never being in possession of such structures; in a few cases they appear in the young tissues, and then gradually die and disappear.

It will perhaps be sufficient to state that there are three types of laticiferous systems the components of which are scattered freely throughout the cortex in the stem; they may, according to their age and the condition of the plant, be partially or wholly filled with latex.

LATICIFEROUS SYSTEM OF *HEVEA BRASILIENSIS*.

In *Hevea brasiliensis* the latex is contained in definite ducts which occur throughout the stems, roots, leaves, flowers, and fruits. The laticiferous ducts in *Hevea brasiliensis* consist of a series of cells, the walls of which break down and thus give rise to the formation of a number of tubes, disposed more or less longitudinally. In some cases the walls of the cells are only incompletely disintegrated, and the flow of the latex is, therefore, not as free as when the partition walls are completely broken down. The disconnected series of cells in all stages of perforation is accountable for many of the variations in yield of latex and rubber described elsewhere.

Scott, in his paper (Lin. Soc. 1885) on the occurrence of articulated laticiferous vessels in *Hevea*, states that the embryo of *Hevea brasiliensis* contains well-developed laticifers, which form a complex anastomosing system; numerous and extensive perforations occur in the lateral walls, though the absorption of the transverse walls may not be complete. Scott believed that the perforation of the lateral walls commenced at an earlier stage than that of the transverse walls. In many parts of his paper he points out that remnants of the transverse walls remain, though large numbers of cells have undergone fusion. The same processes of perforation and

disappearance of cell walls go on in the secondary cortex, and the laticiferous system is, though communicative to some degree, relatively disconnected, compared with the straight, open, non-articulated tubes in certain *Castilloa* and *Euphorbia* species.

This fusion of cells, by the breaking down of the transverse walls to form larger single channels, goes on day by day in the secondary cortex, and the decomposition necessary requires time for its completion. The formation of new laticifers cannot be pre-determined by microscopical examination of the newly-formed cortical cells, the disappearance of the transverse walls taking place irregularly in the cortex; though Ceylon criticisms suggested otherwise, the *de novo* origin in the secondary bark is accepted by microscopists. In a general way it may be stated that the longer the cortex is allowed to remain on the tree the greater the number of cell fusions effected; the greater the number of cortical cells available the larger the number of laticifers, within limits, which are likely to be formed. The laticiferous system in *Hevea brasiliensis* does not increase in size by prolongation of original sacs as in many other plants, but by the disappearance of cell walls; such a system is, despite statements implying the contrary, relatively disconnected (compared with the *Castilloa* or *Euphorbia* type), though there is, as every one knows, communication of some kind between the disintegrated cells in each area. In *Hevea brasiliensis* parts of cross walls may remain, whereas in the non-articulated types these never exist. The laticifers in Para rubber trees have been called "vessels," "sacs," "tubes," etc., but the name is of no great practical importance, and can only confuse the point at issue. The term "fused cells" would probably convey the most correct idea for the laticifers in *Hevea brasiliensis*, as against the word "tubes" for those in *Castilloa*, and the term "sacs" for those in certain gutta-percha yielding plants.

FUNCTIONS OF THE LATEX.

It is well known that a system of milk tubes may or may not occur in different species of plants, and that the presence of a laticiferous system is of importance in determining the identity of species. Several natural orders, such as those which include species of *Euphorbia*, *Castilloa*, *Hevea*, *Funtumia*, *Landolphia*, &c., are characterised by large numbers of plants which possess milk tubes, whereas other natural orders are not known to have any laticiferous species. It is also recognized that the number of species of plants, possessing milk tubes, is greater in the tropics than in colder or more temperate zones, and that many of the latex-bearing plants thrive on rocky soils and in dry districts in the tropics.

If one reflects on the thriving condition of widely different species of latex-bearing plants in the temperate, sub-temperate, and tropical regions, and the behaviour of such plants under various conditions, the difficulty of ascribing a single function or series of

functions to the latex will be manifest. Each species must be considered separately, and in the case of *Hevea brasiliensis* many observations have been made and various theories propounded.

Groom,* when dealing with this subject, pointed out that there was no reason to believe that the functions of the latex in all plants are the same, or that one function should exclude the other.

FUNCTION OF STORING WATER.

The latex of Para rubber consists mainly of water and caoutchouc globules together with small quantities of sugars, proteids, gums, resins, mineral matter, &c. Most of the constituents cannot be regarded as forming reserve food, and even in the case of sugars and proteids their presence in such small quantities would prevent their being of vital importance to the plant in times of emergency. Furthermore, the fact that the tubes arise, *de novo*, by a process of perforation and decomposition, and during their ramifications in the cortex are never in direct communication but contact only with the vital elements of the bast, supports the contention that the small quantities of food they contain are probably of very minor importance to the plant.

The water is, according to most observers, of more importance than the other constituents. It is well known that the flow of latex is largely determined by the humidity of the air and the quantity of water present in the soil. The increased flow which follows rain after a drought is often very remarkable.

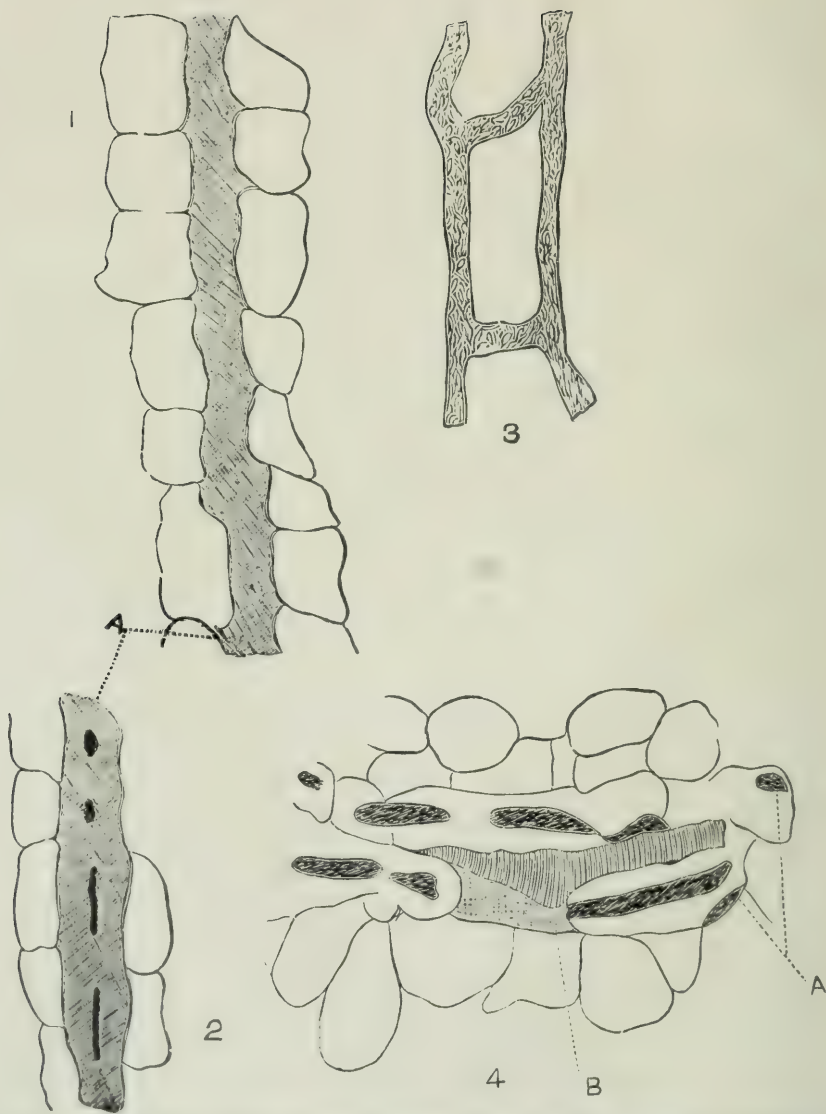
Warming, after studying the vegetation of tropical America, concluded that the latex probably served many functions, one of them being a source of water supply during the dry hot part of the day or year.

Parkin† considered that the latex did not play an important part in nutrition, and inclined to the belief that the laticiferous system served as channels for holding water in reserve to be called upon during times of drought. The exudation and clotting of the milk prevent the many insects entering the tree, but this is not of much importance.

Ridley doubts whether the latex of Para rubber trees acts as a water-store or a protection against drought and points out that though many laticiferous plants thrive in desert areas, the proportion of species belonging to the wet tropical districts is relatively high. He lays emphasis on the latex as a protection against the intrusion of fungus spores and insects into wounds

* Function of Laticiferous Tubes, *Annals of Botany*, 1889.

† Parkin, l



LATEX TUBES OF *HEVEA BRASILIENSIS*, (1, 2); AND *CARICA PAPAYA* (3.)
 (A) LATEX TUBES; (B) VESSEL

and states that many of the trees of the equatorial belt are provided with either a latex, resin or gum, which rapidly exudes when a wound is made.

The complete stripping of the cortex from the base up to 5 feet, and with it the greater part of the laticiferous system, has not, in the case of *Hevea brasiliensis*, resulted in any very bad effects on the tree.

The present appearance of trees, from which large quantities of latex have been extracted, is such as to confirm the belief that the latex is of minor importance to plants freely supplied with water, and that the main source of danger lies in the removal of the cortical and bark tissues often effected in collecting the latex.

It should be recorded that *Hevea brasiliensis* grows exceedingly well on land which is frequently inundated, and in some parts of Ceylon I have seen trees with their tap roots and a large proportion of the feeding rootlets permanently under water and yet yielding over 10 pounds of rubber, per tree, per year. An abundant supply of water, in well-drained land, is not harmful to Para rubber trees.

GENERAL CONSIDERATIONS.

In the accompanying illustrations, figures 1 and 2 represent the latex tubes running in a vertical direction through the stem of *Hevea brasiliensis*. In each case they are surrounded by cells which naturally store up reserve food materials, and in figure 2 curious rod-like bodies are seen in the laticiferous vessels. In some instances the milk tubes are pitted, so that a transference of solutions may be effected from one series of cells to the other. Furthermore, the milk tubes often run very close to those elements of the wood, the function of which is to convey watery solutions from the roots upwards. Figure 3, drawn from a section of the fruit wall of *Carica Papaya*, shows the proximity of the water-conducting elements of the wood to the latex tubes, the latter possessing irregular patches of coagulated indiarubber. In figure 4 the general outline of a series of tubes is shown. On account of these relationships one may be inclined to attach some importance to the theory that the milk tubes are partially connected with conducting functions.

But the fact that the laticiferous tubes may be concerned in conducting solutions, that they contain in their earlier stages a certain quantity of protoplasm, and that nuclei and starch grains may be occasionally found, does not exclude the view that they are mainly excretory or act as water reservoirs.

Generally speaking, the milk tubes contain an emulsion of many substances, such as caoutchouc, resin, gum, sugar, proteids, alkaloids, and fats, and it is therefore very difficult to identify each component in sections under the microscope. Schulerus observed

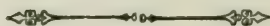
that in the embryo the latex is rich in suspended matters, and that as the plant grows the latex becomes more watery. He suggested that the emulsion of substances might be of use during the early stages. He also noticed that after germination the laticiferous system becomes prominent owing to an increase in the substances in suspension.

Sachs found that if the leaves of some caoutchouc plants were subjected to continuous darkness the quality of the latex was affected, the milk becoming less opaque; a marked change was also noticed if the plants were deprived of carbonic acid gas.

Haberlandt and others found that in some plants the starch grains disappeared from the milk tubes if kept in darkness for two or three weeks, thus suggesting that under certain circumstances the occasional starch grains may be converted into sugar to be used by the plant.

The presence of nuclei in certain laticiferous tubes, absorption in the embryonic stages, the close association of milk tubes with conducting elements in the leaf, and the occurrence of minute quantities of carbohydrates, proteids, fats, and peptinizing ferments, certainly support the idea that under certain conditions the latex contents may be useful to the plant. These substances are present in very variable proportions, and the percentage of valuable ingredients in the latex often diminishes as the result of tapping operations. But as previously pointed out the occurrence of such material in very small quantities prevents one from attributing undue importance to the "reserve food" conception.

The physiological effect of extracting large quantities of latex from trees of known age is being studied at Henaratgoda, where tapping is done more by incision of the laticiferous tubes rather than by excision of dry cortical tissues, but up to the present no remarkable phenomena have been observed.



CHAPTER III.

CLIMATIC CONDITIONS FOR PARA RUBBER

Descriptions of Para by Drs. Trimen and Ule—Para trees in Brazil—Illustration showing Para Rubber in Ceylon—Climate in Ceylon, Straits, Perak, Selangor, Seremban, Singapore, Penang, and Malacca—Java—Rubber-growing areas in Java—Illustration showing young rubber at the Experiment Station, Buitenzorg, Java—Climate in South India—Climate in West Africa—Climate in British North Borneo—Climate in Samoa—Climate in the West Indies—Trinidad—Grenada—Jamaica—Illustration showing Para rubber trees in Malacca—Illustration showing Para rubber trees at an elevation of 3,500 feet in India—Illustration showing Para rubber trees on Sekong Estate, Borneo—Illustration showing the oldest Para rubber tree in Trinidad.

“**P**ARA* occupies a position near the mouth of one of the vast embouchures of the Amazon in about south latitude 1, but the district of the same name extends over a vast forest region to the south and west, throughout which and the enormous forests of Central and Northern Brazil, *Hevea brasiliensis* and allied species are abundantly found. The climate is remarkable for its uniformity of temperature, usually not exceeding 87° F. at midday or falling below 74° at night. The greatest heat recorded is 95°, and the mean for the year is 81°. The rainfall occurs principally during the months from January to June, the maximum being in April, when it reaches 15 inches; for the remaining six months of the year very little rain falls, but there are fine days in the wet season and occasional showers in the dry. During the wet season much of the low-lying country near the Amazon's mouths is flooded.”

Ule,† in his book dealing with rubber in the Amazon district, points out that “the Para tree loses its leaves annually as in Ceylon, and in the flooded regions this occurs when the water is at its highest, *i.e.*, between March and July. It flowers in July and August, and ripens its fruit in January and February. Like most forests in the tropics those of the Amazon are composed of many kinds of trees intermixed, and rubber occurs scattered among the

* Notes on Rubber-yielding Plants, by Dr. Trimen.

† Review by Dr. Willis, “T.A. & M. C.A.S.,” March, 1905.

rest. The lower-lying forests (Vargem or Igapo) are exposed to yearly floods and have a distinct character, differing from those on the higher lands.

There are two chief seasons, a dry and a wet. The driest months are July, August, and September, when the river-level is also lowest. The rains begin in October and last till March, and then decrease; the rain is not however continuous: there are showers with clear intervals. The rivers rise till in January they overflow into the forest; their highest level is reached in March or April and then they fall, leaving the woods dry again. In the lower course of the Amazon itself the water reaches its highest level in June, and this level is often 45 to 60 feet above the lowest. The annual rainfall is usually between 80 and 120 inches, and the mean temperature between 76° and 81° F. There are a great many kinds of trees in the forests, and in a distance of 100 yards one may only find one or two rubber trees."

PARA RUBBER TREES IN BRAZIL.

It has been pointed out by Wickham that the true forests of the Para rubber trees lie back on the highlands, and those commonly seen by travellers along the river side are scattered, poor in growth, and do not give one a fair idea of the conditions under which a good growth of the *Hevea* tree is obtained. The *Hevea* trees found in these forests attain a circumference of 16 to 12 feet in the bole, a considerable difference to the 6-to-7-foot trees recorded by Cross.

The foregoing accounts of the climatic conditions in the native home of *Hevea brasiliensis* should be closely studied by those who intend to cultivate this tree. The rainfall of 80 to 120 inches and temperature of 75° to 81° F., though characteristic of the forests where this species grows luxuriantly, should not, however, be accepted as strictly defining the limits under which Para trees can be grown. But even if the adaptability of the tree were insignificant, it is obvious that in the tropics there are many areas which might reasonably be expected to give good results with this species of rubber. Already the cultivation has aroused considerable interest in Africa, Fiji, Java, Queensland, Seychelles, Borneo, Samoa, Sumatra; and in many of these areas where the climatic factors are approximately similar to those of the Amazon, the industry promises to become as important as in Malaya, Ceylon, and India.

CLIMATE IN CEYLON.

The combination of rainfall, temperature, and elevation required for the cultivation of *Hevea brasiliensis* eliminates many parts of the tropics for this species. In Ceylon, India, and the Straits the large tracts of land in the hilly districts cannot be included in the Para zone on account of low temperatures or unfavourable

moisture conditions. In Ceylon an elevation of 2,000 feet in the Central Province, and 3,000 feet in the Uva Province, is considered to be near the maximum and a rainfall of 70 inches near the minimum for the cultivation of this species. There are trees, planted in 1899, measuring 18 to 26 inches in girth and 22 to 33 feet in height, growing on Weweltalawa, Halgolle estate, on the borders of the Kelani Valley and Yakdessa districts, at an elevation of 3,300 feet. It is being tried in districts having 200 inches of rain per year and also in dry irrigable areas, but reliable results cannot be obtained for many years.

The following are the meteorological details of places in particular districts in Ceylon where Para rubber trees are being successfully grown (Surveyor-General's Report, 1902, and by letter) :—

District.	Annual Rainfall. Inches.	Average Annual Temperature.	Elevation. Feet.
Kalutara (Gikiyana- kanda) ..	150·74	.. — ..	200
Colombo ..	87·52	.. 80·7 F. ..	40
Henaratgoda ..	106·12	.. — ..	33
Kelani ..	161·06	.. — ..	250
Kurunegala ..	84·71	.. — ..	409
Kegalla ..	122·33	.. — ..	729
Kandy ..	81·52	.. 75·5 ..	1,654
Badulla ..	75·28	.. 73·4 ..	2,225
Passara ..	88·91	.. — ..	2,800
Matale ..	84·38	.. — ..	1,208
Ratnapura ..	151·39	.. 79·1 ..	84
Galle ..	91·16	.. 79·9 ..	48
Ragama ..	100·03	.. 79·5 ..	—

In the Colombo, Galle, Ratnapura, Kelani, and Kalutara Districts the rains in the N.-E. and S.-W. monsoons are very heavy ; in the Kurunegala, Matale, Badulla, and Passara Districts they are less violent, but in all the districts mentioned above rain falls every month in the year, the monthly variation being from about five to twenty-four inches.

THE CLIMATE IN THE FEDERATED MALAY STATES.

In the Federated Malay States there is no evidence of the highest elevation at which Para rubber will thrive, though some young trees are growing at Gunong Angsi at an elevation of 2,500 feet. According to Carruthers the growth of Para rubber from sea-level up to 300 feet in the Federated Malay States is better than that at other elevations.

According to the Manual of Statistics published by the Federated Malay States Government "the climate of the Federated Malay States is very uniform and can be described in general terms as hot and moist. The annual rainfall, except in places close to the mountain ranges, is about 90 inches. In towns, such as Taiping, Tapah, Selama, &c., close to high mountains, upwards of 50 per cent. more is registered, the average of ten years' records at the first-named being 164 inches. There is no well-marked dry season. Generally speaking, July is the driest month, but has seldom a less rainfall than $3\frac{1}{2}$ inches. The wettest season is from October to December, and there is another wet season of slightly less degree during March and April. Rain rarely falls before 11 A.M., so that 6 hours of outdoor work can generally be depended upon all the year round.

The average maximum temperature, occurring between noon and 3 P.M., is in the low-country just under 90° and the average minimum occurring before sunrise is just over 70° . The general mean temperature is about 80° . There is very little change in the mean monthly temperature during the year, the average of ten years' readings in Taiping exhibiting a difference of only $3\cdot2^{\circ}$ between the mean temperature of May, the hottest, and of December, the coldest, month of the year.

The variation of temperature with altitude may be taken roughly as a decrease of 3° for every 1,000 feet increase of altitude."

AVERAGE RAINFALL AT PERAK, SELANGOR, SEREMBAN.

	Perak (Teluk Anson), 1894-1903.	Selangor (Kuala Lumpur) 1894-1903.	Negri-Sembilan (Seremban), 1896-1903.
January ..	10·61	6·67	5·21
February ..	7·28	6·29	6·46
March ..	8·11	9·29	8·45
April ..	8·85	10·79	10·56
May ..	7·40	9·13	7·81
June ..	5·56	5·94	5·97
July ..	4·20	4·06	4·59
August ..	5·10	6·14	5·96
September ..	6·51	8·74	5·95
October ..	13·51	13·15	9·19
November ..	12·59	11·87	10·24
December ..	13·27	9·95	7·63
Mean Total..	103·01	102·02	88·02

The above details of rainfall will be of value to all interested the cultivation of Para rubber in Perak, Selangor, and Seremban. An illustration showing mature rubber on the property of the Malacca Rubber Plantations is here given.



Photo lent by Dodwell & Co.

PARA RUBBER IN MALACCA.

TAPPING MATURE RUBBER. MALACCA RUBBER PLANTATIONS, LTD.

SINGAPORE, PENANG, AND MALACCA.

I am indebted to the Principal Civil Medical Officer of Singapore for the following statement showing the average monthly Rainfall, Temperature, and Humidity at Singapore, Penang, and Malacca :—

	Rainfall.			Temperature.			Humidity.		
	Singapore.	Penang.	Malacca.	Singapore.	Penang.	Malacca.	Singapore.	Penang.	Malacca.
	Inches.	Inches.	Inches.	°Fah.	°Fah.	°Fah.	%	%	%
January	13·47	4·26	4·15	78·2	80·8	79·2	81	71	94
February	7·26	2·59	5·36	78·4	80·7	79·1	78	69	92
March	5·75	4·13	2·62	79·7	81·5	79·6	77	69	93
April	10·75	6·82	6·42	80·5	81·2	79·7	80	73	93
May	4·93	9·01	6·27	81·3	80·8	79·6	78	72	94
June	6·50	8·27	6·21	81·0	80·9	79·7	79	72	94
July	6·60	9·19	6·66	80·9	80·2	79·5	78	72	94
August	8·77	13·58	9·12	80·5	79·9	77·6	78	73	94
September	4·65	14·54	8·36	80·6	79·9	79·2	78	72	92
October	5·60	15·82	12·86	80·1	79·7	79·4	79	74	94
November	8·73	10·01	10·74	79·1	80·0	79·2	81	73	94
December	6·96	5·14	5·33	78·3	79·9	79·1	80	73	92

JAVA.

The climate in Java varies like that in Ceylon according to the locality, but we have definite information regarding the climatic factors at Buitenzorg and East Java.

The climate at Buitenzorg differs from that at Peradeniya, Ceylon, in many ways. At Buitenzorg the rain during 1901 to 1904, inclusive, fell on an average of 263 days in each year. The humidity of the air in 1904 ranged from 75 in August to 85 in December, and the average for the years 1901 to 1904, inclusive, was 79. The average monthly temperature ranged in 1904 from 23·6 to 25·3°C. The climate in Buitenzorg is more equable than that at Peradeniya, but a definite periodicity does exist, the rainfall and humidity throughout the year approximating to those at Badulla in the Uva Province of Ceylon.

In East Java the climate is more exacting, and a comparison of the two places is given below.

I am indebted to Dr. Treub for the information in the following synopsis of the monthly rainfall, humidity, and temperature at Paseroean in East Java and Buitenzorg.

CLIMATE DURING 1904 IN JAVA.

	Rainfall in mm.		Monthly Average Mean Humidity.		Monthly Average Mean Shade Temperature in °C.	
	Buitenzorg.	East Java.	Buitenzorg.	East Java.	Buitenzorg.	East Java.
January	417	221	83	77	24.0	27.2
February ..	455	192	85	80	23.6	26.9
March ..	169	287	80	80	24.5	26.6
April ..	204	33	79	76	25.0	27.4
May ..	541	155	80	76	25.3	27.3
June ..	389	27	78	73	25.1	27.1
July ..	312	48	79	71	24.8	26.7
August ..	344	18	75	67	25.1	27.1
September ..	388	—	76	64	25.3	27.7
October ..	799	11	81	64	24.9	28.7
November ..	312	24	80	67	25.2	28.7
December ..	498	110	85	74	24.2	27.9
Average mean, yearly 1901—1904	4,416	1,200	79	71.9	25.0	27.6

Large areas are likely to be planted by companies in suitable parts of Java, and it is of importance to notice that the Forest Department of that island had on March 31st, 1906 approximately 585 acres in Para rubber. Seeds of *Hevea brasiliensis* were sent to Java in 1887, but the plants in that island at the present time are mainly young. Illustrations have been seen showing young rubber on the property of Passir Oetjing estate in the Western part of Java, and satisfactory growth was obtained with the trees planted nine feet apart. I am indebted to Dr. Tromp de Haas, for the illustration showing Para rubber at the Experiment Station, Buitenzorg, planted as stumps in January, 1904; the photograph was taken in December, 1905, so that the trees were then nearly two years old.

I am informed by Mr. R. C. Wright that probably the best parts of Java for rubber-growing are, a portion of Bantam; a great part of the Preanger; a portion of south-east Java; and perhaps also a portion of the north side of Mid-Java. In some of these areas the temperature at about 1,000 feet altitude varies from 68° F. to 90° F: the humidity, except in a portion of Mid-Java, is high.

CLIMATE IN SOUTH INDIA.

In some parts of India the climatic conditions are such as to allow of the cultivation of Para trees up to 3,500 feet above sea-level, and what appear to be satisfactory rates of growth are reported from many parts. Extensive tracts of country are being opened up, especially in the Travancore district, and good results are anticipated on account of the abundance of rich alluvial soil which is reported to exist there.



Photo lent by C. E. Welldon.

PARA RUBBER IN INDIA.

YOUNG PARA RUBBER AND COFFEE, AT 3,500 FEET ELEVATION.

The accompanying illustration will indicate the growth obtainable in the Anamallai Hills, in S. India, at an elevation of 3,500 feet above sea-level. In this particular instance coffee is interplanted with Para rubber. In South India various species of rubber-yielding plants are being tried at high elevations, in conjunction with tea and coffee. The illustration shows Para rubber and coffee both doing well at a high elevation, and the results of tapping on an estate in the Shevaroy Hills are given in the chapter dealing with yields. It is as well to bear in mind that the elevation up to 3,500 feet, in so far that it is affected with changes of atmospheric pressure, has very little influence on the growth of the rubber: far more important are the questions of ranges of temperature and rainfall.

WEST AFRICA.

In the Gold Coast, West Africa, it is, according to Johnson, being grown at an elevation of 1,500 feet above sea-level, where the average mean temperature is about 81·5 F. and the annual average rainfall only 47 inches, and there promises to do better than other rubber-producing plants, indigenous or exotic.

The following table shows the rainfall and number of days on which rain fell during 1900-1904, at Aburi-Gold Coast:—

	1900.		1901.		1902.		1903.		1904.	
	Rainfall.	No. of Wet Days.	Rainfall.	No. of Wet Days.	Rainfall.	No. of Wet Days.	Rainfall.	No. of Wet Days.	Rainfall.	No. of Wet Days.
January ..	1·51	3	2·11	5	0·30	1	0·73	1	1·00	1
February ..	2·30	13	5·32	5	5·03	5	1·09	3	0·55	2
March ..	2·72	4	4·53	8	3·82	9	5·89	6	4·16	8
April ..	4·88	8	4·07	6	7·01	10	2·63	9	1·84	5
May ..	3·14	6	5·48	9	3·27	10	4·56	8	6·24	9
June ..	5·72	15	6·87	10	7·09	11	7·44	11	6·47	13
July ..	2·48	18	6·89	14	2·07	6	3·72	13	2·19	7
August ..	1·49	15	2·57	14	2·93	7	1·58	10	0·65	3
September ..	2·29	14	6·97	24	0·73	2	1·93	11	2·97	6
October ..	5·90	15	4·95	15	7·16	11	4·78	13	2·20	8
November ..	2·53	4	5·43	10	2·16	2	6·60	14	0·52	4
December ..	2·69	5	1·23	6	0·74	3	2·13	5	3·30	5
	37·65	120	56·42	126	42·31	77	43·08	104	32·09	71

(Annual Report for 1904 by Director, Botanic Department, Gold Coast.)

The Aburi Botanic Department regularly distributes large numbers of seedlings of *Hevea brasiliensis* to planters on the West Coast, and where the climatic conditions are very favourable this species is showing satisfactory growth. Several plantations are established

in West Africa in districts where from 80 to 100 inches of rain fall every year; the results should be better than those hitherto recorded in the drier climate at Aburi.

Mr. A. E. Evans, in his report upon agriculture in the Gold Coast Colony in 1906, gives a list of four undertakings which are planting Para Rubber upon a considerable scale. 12,130 plants and 259,000 seeds of *Hevea brasiliensis* were distributed from the Botanic Gardens in 1906.

CONDITIONS IN BORNEO.

Para rubber plants were sent to Borneo from Peradeniya as far back as 1891, and the illustration herewith given shows how well this species of rubber grows in that country. The photograph was obtained from the North Borneo Trading Co., Ltd., and represents well-developed trees on the Para estate at Sekong, being as far as one can judge from the illustration, lightly and carefully tapped on a system other than the herringbone or spiral.

Mr. Cowie informs me that the average yearly rainfall in British North Borneo rubber-growing districts, on the coast, is about 120 inches. In the interior, immediately behind the great central range of mountains, the average yearly rainfall is, according to Mr. Lease, Manager of the Saping Rubber and Tobacco Company, only about 70 inches per annum.

According to the report of Mr. Berkhuisen the rainfall, in the interior, during 1906 was 62·34 inches. The same authority gives the average temperature at 90° F. during the day and 70° F. during the night, in his district.

On the coast the temperature averages about 85° F. during the day and about 80° F. at night.

CLIMATE IN SAMOA.

The Samoan Islands possess a tropical and very equable climate. The usual range of temperature is from 68° to 88° F. According to one authority * "violent winds and thunder-storms are not of frequent occurrence, but severe hurricanes sometimes sweep over the islands, though only in every seven to nine years. The dampness of the air is not so great as would be expected in tropical islands, but it is high enough to meet the requirements of all moisture-loving tropical plants. In the rainy season, which lasts from November to March, the air is usually almost saturated. In the dry season, lasting from April to the end of October, the hygrometer shows in the morning and evening about 90 per cent. and over of complete saturation, but at 2 p.m. about 65 to 75 per cent. is observed; this circumstance is very favourable for the drying of cacao."

* Bulletin, Imperial Institute, London, March, 1904.



PARA RUBBER IN BORNEO.

TAPPING PARA RUBBER, PARA RUBBER ESTATE, SIKONG NORTH, BORNEO TRADING CO., LTD.

"As regards rainfall, the record kept at Apia extends from 1890 onwards. The mean annual rainfall for the 13 years, 1890 to 1902 is 115 inches, and the extremes in that period are a minimum of 89 inches and a maximum of 163 inches. As far as quantity is concerned, the minimum fall is sufficient for cacao and plants needing much water, but on the Samoan Coast the rain is not well distributed in the course of the year, and there are years when periods of drought last too long and are too intense to suit the needs of the cacao plant. If for two or three months in succession the fall is only 0.8 in. per month the yield is very seriously threatened, and for this reason suitable localities at higher altitudes should be sought when selecting land for cacao planting as the rainfall is heavier in such situations". According to Wohltmann the climate in different parts of Samoa is very variable, the rainfall of selected places ranging from 1600 to 3500 mm. per year, and should therefore be as suitable for Para rubber trees as it undoubtedly is for Cacao trees.

WEST INDIES.

It is a most remarkable fact that the West Indian islands, which are well within the Para rubber zone, have not taken a very active interest in the cultivation of this kind. A few old trees occur on some of the islands, and seeds are being applied for in fair quantities. The following particulars of climatic factors will be of interest to those contemplating the cultivation of *Hevea brasiliensis* in the West Indies:—

METEOROLOGICAL DETAILS, ROYAL BOTANIC GARDENS, TRINIDAD.*

	Inches of Rainfall.	Mean Annual re- lative Hu- midity.	Tempera- ture mean maximum.	Tempera- ture mean minimum.	Tempera- ture mean annual.
Record for 1887 ...	64.09	79.00	85.90	69.00	77.40
" " 1888 ...	65.44	80.00	87.50	69.70	78.60
" " 1889 ...	73.79	77.00	87.57	70.10	78.90
" " 1890 ...	82.90	79.00	86.10	69.00	77.50
" " 1891 ...	53.74	76.00	87.80	70.10	78.90
" " 1892 ...	91.14	80.00	87.02	70.02	78.70
" " 1893 ...	92.49	80.00	87.44	68.58	78.01
" " 1894 ...	52.21	78.00	87.80	69.10	78.45
" " 1895 ...	62.23	76.00	87.80	69.50	78.60
" " 1896 ...	66.45	80.00	87.84	70.31	79.07
" " 1897 ...	77.68	80.00	87.91	70.35	79.13
" " 1898 ...	57.63	80.00	87.60	69.20	78.40
" " 1899 ...	46.76	75.00	89.30	69.50	79.40
13 years' average.	68.19	78.00	87.51	69.57	78.54

The rainfall at the Botanic Gardens, Trinidad, appears to be lower than that at Peradeniya, Ceylon, though the average mean annual humidity is in each case about 78. The mean for 18 years

* (a) Cacao, by J. Hinchley Hart, Trinidad, 1900 and (b) L' Agriculture Pratique des Pays Chauds, November-December, 1903; Etudes et Mémoires, La Trinidad, by Gratien Candace.

was 66·48 inches, and the mean at 49 stations in Trinidad for 1905, 68·10 inches. The oldest Para rubber tree in Trinidad is here illustrated.

GRENADA.

I am indebted to the Officer in charge of the Botanic Gardens at Grenada for the following information regarding the distribution of rain in some of the cacao-growing, and therefore probably rubber-growing, districts of Grenada:—

RAINFALL FOR 1903.

MONTH.	ST. GEORGE'S ANNANDALE.	ST. DAVID'S LES AVOCATS.	ST. ANDREW'S DUNTER- LINE.	ST. PATRICK'S SPRINGBANK.	ST. JOHN'S.	
					DOUGALD- STON.	BELVI- VERE.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
January ...	13·75	10·49	6·82	6·69	8·43	15·02
February ...	4·89	4·00	1·37	2·00	3·54	4·59
March ...	5·80	4·91	1·03	1·32	1·76	5·54
April ...	3·54	3·02	0·99	1·34	2·33	3·42
May ...	4·97	2·78	3·17	5·27	4·11	6·91
June ...	14·22	12·40	6·88	8·68	10·91	13·17
July ...	16·77	14·87	11·92	10·13	15·90	22·38
August ...	23·77	19·10	17·83	21·52	18·82	27·98
September ...	14·38	11·00	8·11	11·42	11·07	20·04
October ...	15·72	14·18	7·93	11·19	9·26	19·10
November ...	8·49	5·67	6·02	5·02	4·93	9·08
December ...	22·90	23·77	10·06	11·52	16·06	20·97
Total ...	150·20	126·19	82·13	96·10	107·12	168·20
1902. ...	136·27	100·57	70·89	66·10	102·34	151·29

JAMAICA.

I am indebted to Mr. Buttenshaw for the following information regarding the rainfall in various parts of Jamaica

RAINFALL OVER THE ISLAND.

(From about 138 "average" Stations.)

1904.	N.E. Div.	N. Div.	W. C. Div.	S. Div.	The Island.
	Inches.	Inches.	Inches.	Inches.	Inches.
January ...	5·88	2·60	3·01	2·17	3·42
February ...	8·45	4·19	3·13	2·86	4·66
March ...	6·07	3·18	11·37	6·74	6·68
April ...	4·11	4·18	10·26	5·10	5·91
May ...	6·91	7·33	9·55	6·26	7·51
June ...	18·27	11·61	17·62	13·31	15·20
July ...	5·71	2·34	5·77	3·21	4·26
August ...	7·02	3·25	7·73	3·88	5·47
September ...	5·66	3·89	9·98	6·42	6·49
October ...	19·38	9·42	19·41	18·12	16·58
November ...	17·81	8·60	3·16	1·92	7·87
December ...	6·85	3·13	3·41	2·36	3·94
Total.	112·12	63·72	104·40	72·35	87·99



Lent by MacLaren & Sons.

THE OLDEST PARA RUBBER TREE IN TRINIDAD.

Jamaica possesses plants of an indigenous rubber vine — *Forsteronia floribunda*, Dc., but so far does not appear to have taken an active interest in Para rubber cultivation though saplings of this species are reported to be in a thriving condition.

According to W. Harris, there are many districts in Jamaica suitable for the cultivation of *Hevea brasiliensis*. “ Portions of St. Andrew, St. Thomas-in-the-East, the lower lands in Portland, St. Mary, St. Ann, St. Catharine, Upper Clarendon, Manchester, St. Elizabeth, Trelawny, St. James, Hanover and Westmoreland.”



CHAPTER IV.

CULTIVATION OF PARA RUBBER TREES.

Rate of growth—Sizes of trees at Henaratgoda, Peradeniya, Edangoda, and parts of Ceylon—Illustrations showing Para rubber on rocky hillsides and in drained swampy land—Kegalla, Knuckles, Nilambe, Katugastota, Sabaragamuwa, Wategama, Kalutara, Matale, Baddegama—Spread of foliage each year from 2nd to 30th year—Growth on Vogan Estate, Ceylon—Rate of growth in the Gold Coast—Aburi Botanic Gardens—Tarkwa Botanic Gardens—African Plantations at Axim—Growth of Para Rubber trees in Uganda, Liberia and East Africa—Height and circumference—Rate of growth in Malaya, Perak, Selangor—Carruthers on rate of growth in F.M.S.—Growth in British Borneo—Growth in Java and Sumatra—Growth in Jamaica and Trinidad—Rate of growth in India—Mergui, Shevaroy, Nilgiris—High average incremental growth in the Straits—Leaf-fall—Root system—Propagation of plants—Shade and wind in the F.M.S. and Ceylon—Planting operations—Illustration showing rubber clearing and nursery in Ceylon—Nurseries—Distance of seeds in, and manuring of—Success of basket plants—Fencing—Draining—Distance, Holing and Planting—Distance in planting—Close planting and checking rate of growth—Measurements from estate in Kelani Valley, Ceylon—Systems of planting—Definition of close planting—Advantages and disadvantages of close planting—Distance of tapped trees—Original and permanent distances—Close planting and available tapping area—Number of trees per acre—Distance for rubber alone and catch crops—Pruning Para rubber—When pruning should be tried—Principles and effect—Measurements of straight-stemmed and forked trees in Ceylon—Increase in girth after four months—An experiment at Peradeniya—Inter and catch crops—Cacao, Coffee, Tea, Groundnuts, Lemon-grass, Citronella, Cassava or Tapioca, Cotton, Chillies, Tobacco, Camphor—Future of inter crops—Illustrations showing Para rubber and cacao at Kepitigalla:—Para rubber and Tea on Nikakotua estate—Para rubber and tea on Undugoda Estate, Kegalla—Para rubber and cacao on Dangan Estate, Matale.

RATE OF GROWTH AND SIZE OF MATURE TREES IN CEYLON.

THE rate of growth depends upon the nature of the soil and climate and the care which has been exercised in selecting seed parents and in planting operations. In districts having a rainfall of about 100 inches per year, an average mean annual temperature of 80° F., and soil of medium quality, the trees will grow about six to ten feet in height every year for the first three or four years and attain a height of 80 to 90 feet within thirty years. The growth in circumference is by no means slow; trees one year old from planting may have a circumference of three to four inches, and they usually increase at the rate of four to five inches each year for the first few



Photo by M. Ke'ney Bamher.

PAPA RUBBER IN CEYLON.

KALUTARA DISTRICT.

YOUNG PAPA RUBBER ON ROCKY HILLSIDE.

years when planted as a single product. During the first few years the growth is mainly in length, and the rapid increase in girth is most noticeable after the trees are a few years old. The following table shows the dimensions of trees of known ages at Henaratgoda; the stumps were about one year old when planted.

HENARATGODA TREES PLANTED IN 1876.

Year.	Age.	Measurements.			
		Height.		Circumference.	
		Feet.		Inches.	
1878	..	3	..	30	14
1880	..	5	..	—	16
1881	..	6	..	—	21
1882	..	7	..	50	25½
1883	..	8	..	—	30
1884	..	9	..	63	31
1885	..	10	..	—	43
1886	..	11	..	—	49
1887	..	12	..	—	53½
1888	..	13	..	—	60
1889	..	14	..	—	69¾
1890	..	15	..	—	73
1892	..	17	..	—	77
1893	..	18	..	—	79½
1905	..	30	..	—	109½

PERADENIYA TREES PLANTED IN 1876.

Para rubber trees were planted at Peradeniya in the South Garden near the river banks, above flood-level. They were planted 10 feet apart, probably in 1876 when the stumps were about one year old, and the following were the dimensions of the trees in June, 1905:—

No. of Tree.		Height.		Circumference in Inches.	
		ft.	in.	3 Feet from Base.	
1	..	51	7	..	44
2	..	89	6	..	82
3	..	73	3	..	52
4	..	82	7	..	59
5	..	84	2	..	59
6	..	55	4	..	49
7	..	78	7	..	58
8	..	79	3	..	56
9	..	89	5	..	81
10	..	76	2	..	50
11	..	74	3	..	43

The following list gives the dimensions of the trees planted in 1881 along the river bank, where they are liable to be flooded when the water is high. They are remarkable on account of the growth

obtained when planted so close, the average distance between the trees at the present time being 9 to 10 feet.

Tree.		Circumference, 3 ft. from Base.			Height.	
		ft.	in.		ft.	in.
1	..	4	9		57	2
2	..	4	2	..	87	4
3	..	4	3	..	61	7
4	..	6	11½	..	82	3
5	..	6	8	..	89	1
6	..	4	5	..	81	5
7	..	2	9	..	52	7
8	..	3	7	..	79	6
9	..	5	3	..	84	2
10	..	4	10	..	86	1
11	..	5	5	..	67	4
12	..	5	8	..	78	9
13	..	5	9	..	64	7

Other measurements have previously been taken of the trees on the Forest Department Plantations and are here quoted:—

EDANGODA TREES.

Age.		Mean Circumference, 3 ft. from Base.	
2 years	4.96 inches.
3 „	8.75 „
4 „	12.96 „

YATTIPAWA TREES.

3 years9.37 inches.
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RATE OF GROWTH IN OTHER PARTS OF CEYLON.

The following figures show the dimensions of Para rubber trees, *interplanted with tea and cacao*, in Ceylon:—

Circumference of the Stem in Inches, 3 Feet from the Base.

Age of Trees in years.	Kegalla.	Knuckles.	Sabara- gamuwa.	Katugas- tota.	Pera- deniya.	Nilambe.	Kalu- tara.
2	—	5	—	—	2 to 6	—	5
3	—	—	14	—	10	—	9
4	—	14-16	15	—	—	—	17 to 20
5	21 to 30½	—	21	—	—	—	—
6	—	—	27½	19	—	—	—
7	—	—	31	—	—	—	—
8	—	—	31½	24	—	—	—
9	—	—	65	38	—	15 to 46	—

In districts over 2,000 feet above sea-level, or where the rubber has been planted in inferior or unsuitable soils, the growth is much poorer. On one estate near Peradeniya, 2,200 feet above sea-level, 9-year-old trees only measure 24 to 46 feet in height and 15 to 46 inches in circumference a yard from the ground, and the following dimensions of the trees referred to will be of interest to those



Photo lent by the Kegalle Planters' Association.
PARA RUBBER TREES, 32 MONTHS OLD.
HUNUGALLA ESTATE, KEGALLE.

planters who are trying Para rubber at high elevations in Ceylon and elsewhere:—

No. of Tree:	Length of Trunk. ft. in.	Spread in Widest Part: ft. in.	Circumference 3 Feet from the Base. in.
1 ...	42 0	29 8	46 ¹ / ₂
2 ...	36 0	21 0	22 ¹ / ₂
3 ...	34 6	13 0	15 ¹ / ₂
4 ...	46 10	22 6	24
5 ...	42 6	22 8	22
6 ...	32 5	18 0	22 ¹ / ₂
7 ...	36 6	17 0	25 ¹ / ₂
8 ...	46 8	25 6	33
9 ...	24 4	13 4	17
10 ...	42 8	29 0	35

In other districts where the rubber has been planted in very poor tea and cacao land the growth is often very slow.

The Neboda Tea Co., in their annual report for 1905, state that "the 1904 clearings range from 17 to 27 ¹/₂ feet in height and from 6 to 10 inches in circumference, while last year's basket plants, put out in April-May, from August, 1904, seed, show the best growth: 8 ³/₄ to 12 ¹/₂ feet in height and 3 ¹/₄ to 4 ¹/₄ inches in girth."

Under suitable conditions of soil and climate in Ceylon, one must allow for the full development of the plant; a spread or branch diameter of at least 30 feet for trees 10 years old, and 40 feet for 20-year-old trees might form the basis of calculations where pruning is not adopted, and where the cultivation is intended to be permanent.

The diameters of the branch and foliar system of trees of known ages measured on rubber properties in Ceylon are here given; it must be understood that the growth has been obtained where Para rubber is interplanted with cacao or tea. The growth is very variable. The Para stumps were from one to two years old when planted.

DIAMETER OF BRANCHES WITH FOLIAGE.

Age of Trees. Years:	Matale. ft.	Badde-gama. ft.	Katu-gastota. ft.	Nilam-be. ft.	Knuck-cles. ft.	Pera-deniya. ft.	Sabara-gamuwa. ft.	Watte-gama. ft.	Kalu-tara. ft.
2	2	—	3	—	—	3	15	3	8
3	4 to 4 ¹ / ₂	—	—	—	—	—	—	—	12
4	13 ¹ / ₂	12	—	—	12 to 13	—	19	—	16
6	—	13	—	—	—	—	28	—	17
7	15 to 24	18	—	—	—	—	—	—	20
8	—	—	29	—	—	—	37	—	25
9	—	—	—	17 to 30	—	—	—	23	25
10	32 to 34	—	—	—	—	—	—	28	33
11	—	—	—	—	—	—	—	—	35
13	—	—	—	—	—	—	—	—	46
15	27 to 46	—	—	—	—	—	—	—	—
25	—	—	—	—	—	15 to 43	—	—	—
30	—	—	—	—	—	28 to 40	—	—	—
Elevation in feet.	1,200	50	1,500	2,200	2,500	1,500	600	2,200	100
Rainfall in inches.	77	119	85	130	175	90	170	80 to 90	130

Where the trees are planted closer than 10 × 15 feet apart they will probably show a greater height and smaller circumference. One tree, ten years old, grown more or less in the open, has a spread of 36 feet, whereas one of the same age surrounded with other trees has a spread of only 20 feet. The largest tree in Ceylon, when thirty years old from seed, measured about 90 feet in height and 109½ inches in circumference, and there were many others of the same age which had a circumference of 8 to 9 feet and a height in proportion to the above examples. Several of the old Henaratgoda trees, owing to their being too closely planted, have only a branch spread of 15 to 20 feet in diameter.

GROWTH ON VOGAN ESTATE.

I have been recently favoured with details, by Mr. W. N. Tisdall, indicating the growth of the Para rubber trees on Vogan Estate, Kalutara, Ceylon. The trees were planted in July 1904, and measured in March 1906 (twenty months' growth), 5·88 inches, average circumference at three feet from the base; nine months after (December, 1906), the girths had increased 3·64 inches, the average then being 9·52 inches; October 29th, 1907, the average circumference was 13·60 inches. These measurements show that twenty months after planting the trees measured 5·88 inches, and in the following 1½ years the increase was 7·72 inches, or at the rate of 5 inches per annum.

GROWTH OF PARA RUBBER IN AFRICA.

Evans, in his Annual Report for 1906, states that in the Akim and other wet districts of West Africa *Hevea brasiliensis* should give handsome returns after a few years. Several estates in the Eastern and Western provinces are planting Para rubber in conjunction with other products, and the Botanic Department at Aburi, Gold Coast, supply plants at reasonable rates. Evans also gives the following details regarding the growth of Para rubber trees, up to December, 1906, at the Botanic Gardens, Tarkwa:—

Date of Planting.	Distance Trees planted apart, in feet.	Height December, 1905.	Height December, 1906.	Girth at 3 feet from ground, December, 1905.	Girth at 3 feet from ground, December, 1906.
		feet	feet	inches	inches
June, 1904	15 by 15	20	28	7	12
" " " " " "	12 " 12	16	25	6	10
July " " " " " "	15 " 15	14	24	6	10
" " " " " "	20 " 20	14	25	6	11
" " " " " "	30 " 30	12	27	4	9
" " " " " "	40 " 40	12	27	4	9
" " " " " "	12 " 12	12	26	4	9
Aug. to Sept... ..	12 " 12	12	27	4	10



PARA RUBBER IN CEYLON.
RAKAWANA DISTRICT.

YOUNG PARA RUBBER: TREES 17 MONTHS OLD, MADAMPE ESTATE, RAKAWANA, CEYLON

Photo by C. H. Kerr

RATE OF GROWTH IN THE GOLD COAST.

Plants have been established in the Botanic Gardens,* Aburi, at different dates, and most of them have made favourable growth. Some of the trees only 18 months old were 10 feet high, and had stems 3 inches in diameter. The following table shows the growth of certain trees at different ages in the Gold Coast :—

ABURI BOTANIC GARDENS.

Age of trees in years.		Height in feet		Girth at 3 feet from the ground in inches.		Date of measurement.
10	...	30·25	...	27	...	Dec. 1903
12	...	36	...	40	...	" 1905
4	...	23	...	10	...	" 1903
6	...	29	...	16	...	" 1903
3	...	17·5	...	6·5	...	" 1903
5	...	27	..	12	...	" 1905

At the present time the cultivation of Para rubber trees in West Africa is somewhat experimental, but it is anticipated that this phase will soon be passed. The African Plantations Ltd., according to the report issued in March 1907, have several thousands of young plants growing on their property at Axim. Plants which were received in June, 1906, had grown to a height of 3 to 4 feet in 8 to 9 months and the best developed showed a height of over 6 feet 9 inches and a girth of 2½ inches.

Small plantations of this species have been made in Liberia and there is every reason to feel satisfied at the growth already obtained. The experiments made in many parts of East and Central Africa are not as encouraging as those in West Africa, the dry climate and occasional frost preventing continuous and rapid growth. The Hevea plantations in the Congo Free State and the German Colonies are not yet in a sufficiently advanced state to allow one to make any very definite assertions.

GROWTH OF PARA RUBBER TREES IN UGANDA.

According to H. M. Commissioner's Report a Para rubber tree, 4½ years old, growing in that Protectorate, was 27½ feet high, with a girth of 12½ inches 4 feet from the ground. About 200 trees, 2¼ years old, grown from seed were about 17 feet high. There has been much commercial activity in regard to this product, and ventures on a large scale were pending during 1906.

RATE OF GROWTH IN MALAYA.

The growth in most parts of the Straits Settlements and Federated Malay States is considered to be very encouraging and superior to that obtained in many other Para rubber-growing

* Johnson, Report on Rubber in the Gold Coast, 1905.

countries. In Perak* 11-year-old specimens may be 70-75 feet high and have a mean girth of $4\frac{1}{2}$ feet, at 3 feet from the base.

	Age in Years.	Circumference at a Yard from Base in Inches.	Height Ft.
Trees in F.M.S. ..	$3\frac{1}{2}$	$17\frac{1}{2}$	—
..	4	$22\frac{1}{2}$	30
..	10	54	65.75
At Perak.† ..	10	50	79

Trees on an estate in Selangor grew to a height of over 30 feet and attained a girth of 19 inches in four years. At Perak, an 18-year-old tree growing at Kuala Kangsar, has a girth of 8 ft. 6 inches at a yard from the ground. Phenomenal growth in some parts of the Straits is often met with, trees 18 months old being sometimes nearly 30 feet high, and trees 8 years old having a circumference of 45 or more inches a yard from the ground. According to Carruthers the rate of growth in the Federated Malay States cannot be definitely given, but 3 to 9 inches girth in 2 years, 10 to 30 inches in 4 to 6 years, and 30 to 60 inches in 7 to 10 years are quoted as averages by him.

GROWTH IN BRITISH BORNEO.

The measurements of 20 Para rubber trees on an estate belonging to the British Borneo Para Rubber Co., Ltd., have been received. Twelve 20-month-old trees show an average height of 20 ft. 8 in. and a girth of $8\frac{3}{4}$ in., at 3 ft. from the ground. Eight trees 17 months old show an average growth of 19.7-9 ft. in height and $7\frac{7}{8}$ girth. The growth is very satisfactory, and compares favourably with that in other Eastern places.

GROWTH IN JAVA AND SUMATRA.

The illustration given elsewhere indicates the rate of growth obtained at Buitenzorg, but detailed statistics showing the average sizes of trees of known ages in that island are not available. Many parts of Java are relatively dry and in such the Para rubber plants have not developed very rapidly; in other districts provided with an abundant rainfall the growth is reported to be quite equal to that in most parts of Ceylon.

Hevea plantations in Sumatra have, during the past year, attracted considerable attention on account of many reports indicating very rapid growth. A large number of trees are planted on rich, volcanic soil in areas supplied with over 100 inches per annum; the rate of growth on many of these properties appears to be quite equal to the best recorded development in the Federated Malay States. An average growth, in circumference, of 5 to 6 inches per annum is accepted for most of the good estates in Sumatra.

* Annual Report, F. M. S., for 1902, by Stanley Arden.

† Agr. Bul. of the Straits and F. M. S., June, 1902.



PARA RUBBER: BANDJASARIE, JAVA.
TREES 26 MONTHS OLD.



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JUNGLE LAND IN SOUTH INDIA FOR RUBBER CULTIVATION.

GROWTH IN THE WEST INDIES.

The rate of growth of *Hevea brasiliensis* is indicated by the illustration, given elsewhere, of the oldest tree in Trinidad. There are very few records at present available which show the average annual incremental growth in parts of Trinidad and Jamaica where this species has been planted, though the general opinion appears to be that the growth is not as favourable as in the East Indies.

In a recent issue of the West Indian Bulletin, Sharp states that *Hevea brasiliensis* will not yield as early or as abundantly as *Castilloa elastica* and is not as suitable as a shade tree for cacao; he further states that in dry districts, Hevea will probably thrive better than Castilloa, on account of its being a much hardier plant. These statements were intended to apply to Jamaica only: it is obvious they do not concur with the results of experience in the East Indies.

The interest in Hevea cultivation in Trinidad is very promising. Hart states (Bulletin No. 55, July, 1907) that the seeds are in great demand and that the crop on the Government trees will be inadequate to meet the demand: he also informs us (Bulletin No. 54, April 1907) that the largest tree under cultivation in Trinidad, depicted in the illustration previously referred to, stands a short distance from the residence of the Governor, Government House.

Hawai, Barbados, St. Lucia, Montserrat, Dominica, etc., have not yet taken up a very prominent position in the cultivation of *Hevea brasiliensis* but whether this is due to unfavourable climatic conditions or otherwise is not clear.

RATE OF GROWTH IN INDIA.

The following figures showing the dimensions of nine-year-old trees in Mergui have been given by Colonel W. J. Seaton:—

No.		Height in Feet.		Circumference in Inches, at 2 ft. from the Ground.
1	..	39	..	29½
2	..	34½	..	37
3	..	40	..	38
4	..	43½	..	40½
5	..	36½	..	39½
6	..	38½	..	27½
7	..	36½	..	31
8	..	30	..	18
9	..	31	..	27
10	..	21½	..	18½

In many parts of Southern India, Para rubber is being more or less successfully grown up to 3,500 feet above sea-level. Trees at an elevation of 2,500 feet have attained a height of 18 feet in three years, a circumference of 42 inches in 17 years, and nearly 60 inches in 22 years

On the Shevaroy Hills, at an elevation of 3,400 feet, Para rubber trees are reported to be about 10 inches in circumference when three years old; others are reported at 3,600 feet in the Nilgiris and the Anamallais to be from 9 to 13 inches in circumference and 19 to 29 feet in height, when three-and-a-half years old. On many of these properties the rubber is used as shade for coffee, and from all accounts the latter is thriving under the shade of Para and Castilleja rubber.

The Para rubber trees in some parts of South India do not appear to increase much more than 3 to 4 inches in circumference per year, and a girth of 20 inches in 5 years would be considered satisfactory.

Speaking in quite a general way it is fairly correct to say that the average growth obtained in the good soils of Malaya, when the rubber is grown as a single product, is better than that in Ceylon, India, or in West Africa, but that local areas in each country, and especially in the drained black soils of Ceylon and along the Malabar coast of India, show excellent growth of Para rubber.

LEAF-FALL.

The Para rubber tree is not evergreen. During the first two or three years the young tree may retain its leaves and show a nett increase in foliage at regular intervals. After the second or third year, however, the tree annually drops its leaves, but quickly puts on a fresh supply of young foliage. When growing under healthy conditions the trees in Ceylon and the Straits usually drop their leaves in February and March; in badly-drained places the foliar change is very irregular. The tapping operations are believed, by many persons, to change to a varying degree the periodicity of leaf-fall and production.

In its native home the tree becomes leafless between March and July.

The annual leaf-fall should be taken into consideration if the Para rubber trees are interplanted with other products, as the leafless phase usually occurs when the dryness and temperature of the air are at the maximum, and the intercrops will therefore be exposed to the dry hot winds at a time when rain is not expected.

ROOT SYSTEM.

The tree has a very well-developed root system which may ultimately crowd out many intercrops if planted too close. The tap root may grow to a considerable length and the lateral rootlets form a very compact mass. It is on account of the rapidly-growing, compact, and superficial root system that plants such as the coconut and other palms, tea and coffee, cannot be grown successfully for very many years in conjunction with Para rubber. The lateral roots grow at varying rates according to the conditions prevailing, but if

ROOT GROWTH OF PARA TREES.



Photo by Chas. Northway.

PARA TREES 13 YEARS OLD AND THEIR ROOT SYSTEMS.



Photo by Ivor Etherington.

PARA RUBBER IN CEYLON.

A PARA RUBBER CLEARING AND NURSERY, SOUTHERN PROVINCE OF CEYLON.

grown alone on moderately good and flat land, an incremental minimum yearly increase in radius of about one to two feet can be allowed for. In six to seven years the lateral roots (growth of which is of high importance) of plants distanced $12 \times 12'$ may be expected to form a compact mass; planted $10 \times 15'$ the larger distance will be more or less completely covered in 7 to 8 years.

RATE OF ROOT GROWTH.

The root system of young Para Rubber plants (especially the outer zone), though superficial, is not as compact as that of an old tree. There are always a large number of lateral roots on young plants which grow much more rapidly than the rest, but the *compact* root system does not usually advance at a rate much above one to two feet, radially, each year. Individual roots have been described as growing at the rapid rate of one foot per month; but no figures having been published, I meanwhile judge the rate of growth of the compact root system from observations made when carrying out trench-manuring experiments with young trees at Peradeniya.

SHADE IN JAVA AND SINGAPORE.

I was much impressed with what I saw on one estate in East Java during May 1908. In parts of East Java the dry season may extend over a period of six or seven months and it has become a planting custom in that area to develop everything under the shade of trees—especially Dadaps; Liberian, Arabian and Robusta coffee bushes, and Cacao trees are all under the same shade, though in the adjacent island of Sumatra the former products are grown in the open. On the estate to which I refer the Para rubber trees, now two years old, had been grown under the shade of high Dadap trees; they were spindly and backward for their age and I consequently advised the owner to ring the shade trees to let in more light.

At the Botanic Gardens, Singapore, Mr. Ridley showed me a number of very large Hevea trees which had been developed under the shade of tall forest trees. The trees were fifteen to twenty years old and several were quite equal in size to others which had been grown in the open. The seedlings were planted among the forest trees and allowed to develop as best they could; the fact that such fine development can be obtained proves how the plant can overcome the effect of unfavourable conditions.

In Java and Sumatra the best growth of Hevea is obtained without permanent shade; the foregoing examples are, however, of interest.

SHADE AND WIND

In the F.M.S., according to Carruthers, the shading of rubber plants is generally of very little importance owing to the absence of severe droughts in that part of the tropics: it is only recommended in districts where "seed at stake" is the method of planting, and where dry weather may occur within ten weeks after planting.

It would be unfortunate if the Para rubber tree required a permanent shade as there are but few shade trees which could be relied upon to always outreach the tops of tall rubber trees, especially when the latter have never been pruned and when planted very close. Only trees such as *Albizzia moluccana* and perhaps *Erythrina lithosperma* would combine the quick growth and spreading of branches which would be necessary. Trees of *Peltophorum* and *Pterospermum* species, &c., though attaining huge dimensions, grow at too slow a rate—especially when cultivated in conjunction with other tree forms.

Para rubber trees generally develop better if shaded after being planted, and a light shade for the first and second years such as is given by cuttings or plants of *Erythrina* species is beneficial. After their second year they grow satisfactorily without shade.

Windbelts are generally only necessary during the early stages, owing to the protection from wind which the mature trees give to one another and their general strength; special forest belts can be disregarded except in very windy places, where the retention of jungle or planted belts to break the wind is a feasible way out of the difficulty.

PLANTING OPERATIONS.

Nurseries.—If clearing and holing have been completed, the seeds should be planted as soon as they have germinated. The seeds germinate in a few days if regularly watered. If it is intended to plant stumps in the following year, a well-prepared nursery should be used. The seeds can be planted from four to six inches apart. The larger the plant—in an interval of 9 to 12 months—the better. Good growth has been obtained by adding cattle manure and leaf-mould to the nursery soil before sowing the seeds; the same nursery should not be used twice unless it has been liberally manured. An application of a well-balanced artificial manure to the nursery plants when about four months old will also help them on and give better stumps for planting in due course. The use of seed-baskets is to be recommended as there is minimum interruption in the root development during planting operations; the success with which stumps can be used has led to the disuse of baskets in many districts. Considering that so few trees are planted per acre, and that baskets are so cheap, the disuse of the latter at the expense of the interruption in development of the rubber plant is to be regretted. The Neboda Tea Co., Ceylon, in their annual report for 1905, attribute the success of recent clearings to the use of basket plants.

Fencing.—This work is necessary if the vacancies are to be kept at a minimum. Animals attack the Para rubber plants at all stages, particularly during the first and second years, and the amount of



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CLEARING LAND FOR RUBBER IN CEYLON.



Lent by Maclaren & Sons.
YOUNG PARA RUBBER PLANTS IN BASKETS: JAVA.

damage done to young clearings by rats, hares, porcupines, pigs, deer, and cattle cannot be too seriously considered. If it is intended to cultivate catch crops which are equally attractive to animals, fencing is imperative. The boundaries of newly-planted clearings are often enclosed in coarse wire netting, but where the rubber is planted in established products, such as tea, cacao, coffee, &c., it is usually sufficient to fence around each plant, either with netting or sticks. When coarse netting is used the plants are protected by a circle of netting about six to nine inches from the plant to a height of 3 or more feet.

Draining.—It is erroneous to suppose that because Para rubber is a forest cultivation draining is unnecessary. Draining is as necessary for rubber trees as it is for any other product in order to encourage the free circulation of air, water, and food solutions throughout the soil, and to check wash on steep hillsides.

The distance of the drains from one another and their size must depend upon the soil conditions. In swampy and boggy land, little above the water-level, the drains should be as wide and deep as possible, either between each row of trees or in exceptional cases around individual trees. Several areas in the low-country of Ceylon, consisting of bogs rich in organic matter, have been converted into good rubber land by making drains two to three feet wide and three to four feet deep, and heaping the earth in the middle to form a dry soil on which the rubber plant can live for a couple of years. An illustration is given elsewhere to show swampy land which by means of good drainage has been converted into good rubber soil.

On hillsides the drains need be only about one to one-and-a-half feet deep. They should be made at right angles to the slope in order to check the formation of gorges. The distance of the drains from one another will vary according to the slope and climatic conditions; on flat land a distance of 60 to 70 feet seems sufficient, whereas on steep hillsides 20 to 30 feet is not too close. The illustration reproduced elsewhere, shows a young rubber plantation established on very rocky land.

Distance, Holing, and Planting.—It is a principle recognized in forestry that close planting will give tall trees, and wide or open planting thick trees. The object in planting Para rubber is to produce trees which will, as early as possible after the fourth or sixth year, give a straight stem of at least ten to fifteen feet in height and a circumference of 20 inches or more. Such trees can be tapped. If the trees are very tall, but have a circumference of less than 20 inches, tapping operations are generally impossible owing to the smallness of the available tapping area from 6 feet downwards. And such trees 8 years old are known, the undesirable result being the outcome of too close planting and not thinning-out or pruning the trees at the proper time. In parts of Ceylon Para trees have

been planted 10' \times 10,' 12' \times 12,' 14' \times 14,' 15' \times 15,' and 20' \times 20.' It should be mentioned that trees in the Federated Malay States, planted 36' \times 36', showed contact of branches in nine years, and in Ceylon the branches of trees planted forty feet apart have been known to meet in ten years.

In order to allow the plants to develop freely in circumference the maximum distance should be allowed, as the desired length of trunk is usually obtained even when the Para rubber tree is grown in the open. From considerations of the condition of trees from 2 to 20 years old, the following table is compiled in order to show the probable number of Para rubber trees of known age an estate can bear without interfering with the natural growth of the plants:—

Age of Trees.		Total spread of the Branches in Diameter. ;		Number of Trees per Acre.
Four years old	..	12 feet	..	302
Six "	..	15 "	..	193
Eight "	..	25 "	..	70
Ten "	..	30 "	..	30
Twelve "	..	35 "	..	35
Twelve "	..	35 "	..	35
Fifteen "	..	40 "	..	27
Twenty "	..	40 "	..	27

This shows the approximate number of trees to the acre at different ages without any interference of the branches of adjacent trees with one another. There is, however, no objection to the branches of trees partially overlapping, and it is more than likely that any excessive branch development will be kept back by pruning or pollarding rather than by reducing the number of trees below about 100 to 150 to the acre.

Holing.—The question of *holing* should be well considered, as the Para rubber plant is a greedy feeder and responds to generous treatment. The holes should be 1½ feet deep and as wide in area as possible, and if made 1½ \times 2 \times 2 feet they would not be any too large. The larger the holes, the better for the plant. Good holing will give the plants an excellent start; the dribbling in of seeds in small al vangoe holes is not to be recommended. It is hardly necessary to point out that the planting operations should be carried out when rain is plentiful; the plants should, if possible, be stumped but every care taken to avoid unnecessary destruction of sound roots. The stumps will stand one or two weeks' drought, but if dry weather continues for a long period the soil around the plants should be shaded. In some instances, where it has been necessary to plant in moderately dry weather, the nurseries have been flooded for two or three days prior to the plants being removed, and the results have been considered good.



Lent by Maclaren & Sons.

PLANTING YOUNG PARA RUBBER STUMPS.

DISTANCE IN PLANTING.

Johnson recommends planting $15' \times 15'$ to $20' \times 20'$, and afterwards thinning-out. If the estate is planted for rubber alone, all ideas of catch crops are disregarded, and a distance of 10 by 10 feet adopted in planting, the trees when six years old will certainly have their foliar and root systems in contact. On such an estate individual trees might be tapped on the full spiral system until they died, and thus make room for the further development of the remaining plants. It should be mentioned that there are trees which have been grown in moderately rich soil for over twenty years, and though they are still only from eight to ten feet apart they have a circumference of from forty to over eighty inches, and a branch and foliar system measuring less than thirty feet in diameter. I have frequently seen Para trees which, though planted the same distance and over 10 years old, did not appear to be too crowded.

DISTANCE IN PLANTING AND CHECKING GROWTH.

The rate of growth is ultimately influenced by the distance the trees are apart; trees planted about ten feet apart, after attaining a girth of about twenty inches, do not subsequently increase in girth at the same rate as do those widely planted. On a Kadugannawa estate, Ceylon, where the trees are planted about ten feet apart, those trees on the boundary have continued to grow in circumference after those in the middle of the plantation have almost stopped growing; the trees on this block were, at the time these observations were made, about nine years old and had hardly ever been tapped. It is, therefore, obvious that a permanent distance of ten feet apart is far too close for Para rubber, though many estates have been so planted and will require systematic thinning-out later.

The old Henaratgoda trees, now about 22 years old and originally planted about twelve feet apart, measured, according to Willis, 30 inches in girth in 1897; but in 1907 the average girth was only about $36\frac{1}{2}$ inches; the annual increase in circumference having been much less than one inch during the last few years

In the "Financier" of September 27th, 1907, the following measurements of trees planted at different distances were given, the details being supplied from estates in the Kelani Valley, Ceylon:—

30-ACRE CLEARING, PLANTED 1903, (10 BY 10 FEET).

		TREES MARKED NOS.										Average.
		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	
		ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
January,	1906 ...	6	$5\frac{1}{2}$	$8\frac{1}{2}$	$3\frac{1}{2}$	4	3	$4\frac{1}{2}$	$5\frac{1}{2}$	6	$6\frac{1}{2}$	5.3
January,	1907 ...	11	9	15	6	7	4	7	9	9	9	8.6
July,	1907 ...	13	$10\frac{3}{8}$	$18\frac{1}{2}$	$7\frac{1}{2}$	$8\frac{1}{2}$	$5\frac{1}{2}$	$8\frac{1}{2}$	$11\frac{1}{2}$	$10\frac{1}{2}$	$10\frac{3}{8}$	10.3

PARA RUBBER.

50-ACRE CLEARING, PLANTED 1904, (15 by 15 feet).

			TREES MARKED NOS.										Average.
			1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	
			ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	
January,	1906	...	3 $\frac{3}{4}$	3	3 $\frac{1}{2}$	3	3 $\frac{5}{8}$	2 $\frac{3}{8}$	4 $\frac{3}{4}$	5 $\frac{1}{2}$	2 $\frac{3}{4}$	3 $\frac{1}{4}$	3·5
January,	1907	...	7	6	5	6	10	6	8	11	4	6	6·9
July,	1907	...	10 $\frac{1}{8}$	8	7 $\frac{5}{8}$	8 $\frac{3}{4}$	12 $\frac{3}{4}$	8	11 $\frac{1}{2}$	14 $\frac{1}{2}$	5 $\frac{1}{2}$	9 $\frac{1}{2}$	9·5

These measurements appear to show that the closely-planted trees after three years have an average girth of 5·3 inches against an average girth of 6·9 inches for the same aged trees on the estate more widely planted. If these figures represent what is obtainable by a difference in age alone, they are very valuable; a difference in the rate of growth is not usually expected during the first four or five years. In a later issue of the "Financier" the following further measurements on the same estate, made on September 30th, 1907, are also given:—

30 ACRE CLEARING, 10 BY 10 FT.—1903

Numbers.										Average.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	
ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
14 $\frac{3}{4}$	11 $\frac{1}{4}$	20 $\frac{1}{4}$	8 $\frac{1}{4}$	9 $\frac{1}{8}$	5 $\frac{1}{2}$	9 $\frac{3}{8}$	12	12 $\frac{1}{4}$	10 $\frac{1}{4}$	11·35

50 ACRE CLEARING, 15 BY 15 FT.—1904.

Numbers.										Average.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	
ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
11 $\frac{1}{2}$	8 $\frac{1}{2}$	8 $\frac{3}{8}$	10	15	9	12 $\frac{1}{4}$	15 $\frac{1}{2}$	5 $\frac{3}{4}$	10 $\frac{1}{4}$	10·61

1903 planting (selected trees) 22 $\frac{1}{2}$ ins., as against July, 1907., 20 $\frac{3}{4}$ ins.

SYSTEMS OF PLANTING

It has been previously* explained that in the planting of Para rubber there are approximately five systems which may be mentioned:—

(a) Close planting—permanent; (b) Close planting and thinning-out; (c) Wide planting—permanent; (d) Wide planting with catch and intercrops; (e) Interplanting with herbaceous and arborescent plants.

* Science of Para Rubber Cultivation; Messrs. A. M. & J. Ferguson, Colombo, 1907.



Photo by C. H. Kere.

PARA RUBBER IN CEYLON

RAKAWANA DISTRICT.

TAPPING MATURE RUBBER TREES. MADAMBE ESPALU, RAKAWANA, CEYLON.

WHAT IS CLOSE PLANTING ?

To define close planting is a difficult matter, and though actual figures may be quoted, they are subject to modification according to the physical and chemical properties of the soil, and the nature of the climate in which it is proposed to grow the plants. The term—close planting—admittedly implies the planting of the trees at a distance which is not sufficient to allow of the full development of all parts of the plant; the latter is determined by the natural vitality of the plants and the nature of the soil and climate. Medium distance planting in a poor cabook soil, or in a washed out clay, above 2,500 feet in Ceylon, would be regarded as close planting in a rich alluvial soil in the low country of the same island. The trees should be planted at such a distance that they will rapidly develop and take possession of the whole of the soil; their development is controlled by the amount of food which the soil supplies, and it is generally conceded that the better the soil, and more forcing the climate, the greater must be the distance allowed.

Disregarding the differences in quality of alluvial, cabook, swampy, forest and chena land, from sea-level up to 3,000 feet in Ceylon, and the allowances to be made accordingly, it may be generally stated that on a soil similar to that at Peradeniya, Ceylon, a distance of ten feet apart, or less, for trees of *Hevea brasiliensis*, may be designated as close planting; one of fifteen feet apart, as medium distance; and one of twenty feet apart or over as wide planting. These distances are subject to modification according to local conditions, and are here given only to provide a basis for comparison.

ADVANTAGES AND DISADVANTAGES OF CLOSE PLANTING.

The advantages of close planting are that there is a larger number of trees on a given acreage; (2) the ground is better protected with the root and foliar systems, and consequently expenses in weeding are greatly checked, and soil loss thereby reduced; (3) the rubber might, perhaps, be harvested cheaper; (4) the cultivation is essentially one of rubber trees which presumably have a higher value than other trees of economic importance, and the method of cultivation over all the soil becomes the same; (5) the inevitable proportion of poorly developed, stunted, and damaged trees is not as serious; (6) it is generally easier to thin out a densely planted estate than to interplant a widely planted one.

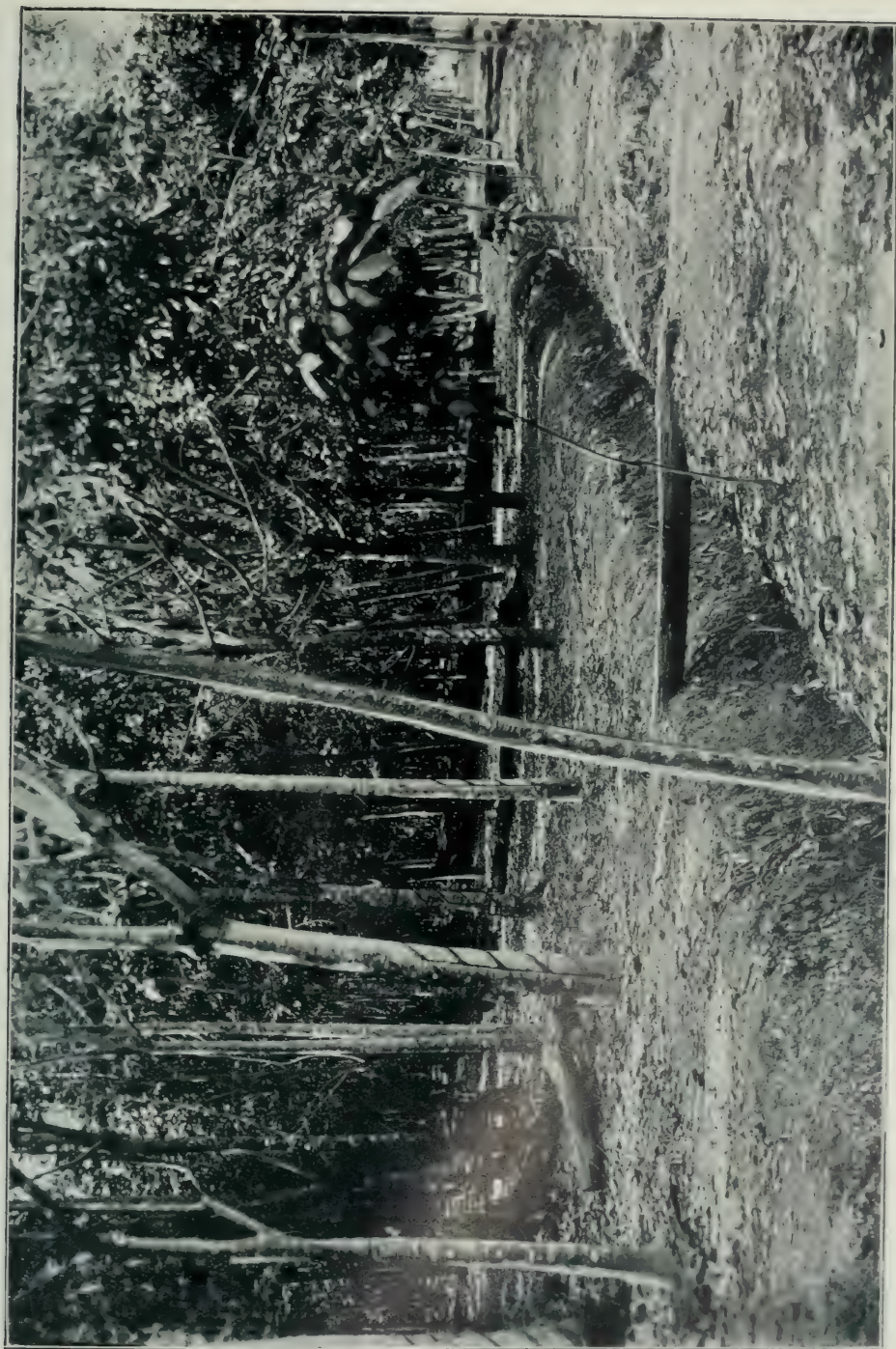
The disadvantages are; (1) there may be considerable interference in the development of all parts of the plant and the resultant trees be dwarfed and lacking in vitality; (2) the stems will tend to become thin, long and spindly, and the thickness of tappable cortex (bark) reduced; (3) diseases are given a greater chance of originating and may spread more rapidly because the parts of the plant are nearer to one another or in more frequent contact.

DISTANCE OF TAPPED TREES.

There is another point which appears to have been overlooked in connection with this subject, and that is the retardation in growth which must follow regular paring or tapping. It is no exaggeration to say that most of the old trees in Ceylon or Malaya were not systematically tapped until the last few years, and but few estates can point to acreages which have been regularly tapped, throughout successive years, from the time the old trees attained their minimum tappable size. Whenever cortical tissues are removed or mutilated, the energy of the plant is partly diverted to the production of new tissues in the affected area, for the time being the intimate connection between individual vital structures and that of the latter with cells which have less important functions, is interrupted; such changes must affect the future development of the plants, especially when of repeated occurrence from the 4th, 5th or 6th year onwards. In the absence of any measurable effects following the tapping of trees one can only generalise and state that the sizes of trees so treated will probably be less than those of specimens which have never had their bark so excised and otherwise mutilated.

ORIGINAL & PERMANENT DISTANCE.

It is taken for granted that the reader is familiar with the sizes of Para rubber plants from their first to their thirtieth year, in different soils and climates; the question to discuss is whether the original should be the permanent distance. No one who has seen the uncultivated thirty-year-old trees at Henaratgoda can doubt that such specimens require, at the very least, a distance of thirty to forty feet, if they are to be allowed to continue in their growth and maintain a healthy constitution; what the required distance will be when they are 40 to 50 years old is very difficult to predict. In striking contrast to these are the thin, tall stems of two to four-year-old trees, and the poor lateral spread of the foliage when trees have just reached the tappable size. Between the first year of tapping and that represented by the old Henaratgoda trees, is a gap of nearly 25 years—probably the equivalent of a longer period when the newly-bearing trees are regularly tapped, throughout successive years. I am of the opinion that it is not advantageous to plant, in a clearing, Para rubber trees alone, at a distance which they will require when thirty years old; we are dealing with a species which does not, like cacao and similar plants, attain the greater part of its maximum size in the first six or seven years, but with one which continues to grow, year by year, and even when thirty years old, still keeps on growing and throwing its roots into new soil. Though Para rubber trees continue to grow in this manner and the ultimate size attainable can only be roughly guessed at from our scanty knowledge and experience, yet we know that when their stems are



RUBBER IN MALAYA.

8 YEAR OLD RUBBER BELONGING TO THE FEDERATED SELANGOR RUBBER CO.

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only 20 inches in circumference they yield marketable rubber in very satisfactory quantities. Four to six years is a long time to wait for the first returns, and from a commercial standpoint the distance at which trees can be planted, without entailing undue interference in general development, and brought into bearing in their fourth year onwards, is one worthy of every consideration.

When the trees are widely planted they come into bearing as early as when closely planted, but there is no very great difference in the dimensions of trees planted at widely different distances, up to their fourth year; the growth in the first four years is not as conspicuous as in later years, and even in the richest soils there is, despite ridiculous statements implying the contrary, a limit to the root and foliar development of Para rubber plants just as there is to parts of other plants.

CLOSE PLANTING AND AVAILABLE TAPPING AREA.

The main justification for closely planting Para rubber trees is the increased tapping area which is available from the fourth year onwards.

The object of many persons who planted this product, two years ago, was to place their rubber on the market as early as possible, in order to benefit by high prices and to obtain quick returns. The results obtained by close planting can be made clear by calculating the available tapping area from the data previously given. The table given below shows the tapping area per acre possible when the plants are distanced from 10 to 20 feet apart:—

Distance of Trees in Feet.	Number of Trees to the Acre.	Available tapping Area per Acre at the End of the 4th or 5th Year in Square Inches ; Base to 5 Feet.
10 by 10	435	522,000
10 by 15	290	348,000
20 by 20	109	130,800

From this table it is obvious that by planting 20 by 20 feet the available tapping area at the end of the 4th or 5th year is reduced to about one-quarter of what it would be if planted 10 by 10 feet. On an estate planted 10 by 10 about 5 per cent. of the trees could be killed out at the end of the 4th year, and a larger proportion dealt with likewise in succeeding years, until by the end of the 8th year an average of about 250 trees per acre would remain. The thinning-out of Hevea trees is, however, an unsatisfactory process and very few estates are now being planted with this object in view. A widely planted rubber estate with an intercrop of cacao is apparently more valuable and less troublesome than a closely planted estate of rubber trees only.

The distance of 10 feet by 10 feet suggested on the above calculations is still open to the objection that the soil will be considerably exposed during the first few years, but this can be overcome by the interplanting of cuttings or plants of *Erythrina lithosperma* (Dadap), a species which can be made to afford shade for the first few years and at the same time provide a rich mulch for the benefit of the young Para rubber plants.

On several estates the rubber trees have been planted 8 by 8 feet and even closer, on the assumption that half of them would die from one cause or another or could be cut out when the growth became too dense.

The use of the Dadap or Albizzia stumps between Para rubber plants would, I believe, be accompanied by good results. The presence of a young Dadap between every two rubber plants would not interfere with the growth of the latter for several years, as is obvious from the previous considerations regarding the rate of growth of the lateral root system.

PRUNING YOUNG TREES.

The Para rubber tree naturally grows to a tall slender tree, and it remains to be seen how by pruning or pollarding the young plants an increase in circumference may be obtained at the expense of the growth in height. Considering what has been accomplished with tea, where plants ordinarily growing into fairly stout trees over twenty feet high have been converted into small bushes two to four feet in height, it would be idle to predict the possibilities with Para rubber. The prevention of the unnecessary growth in height may well form the subject of many experiments.

The plants can be prevented from growing into slender woody structures by removing the terminal bud with a knife or thumb-nail pruning, or, as is more commonly the case, by pruning the terminal young leaves and the enclosed bud. If the central bud is effectively and repeatedly removed, without doing considerable damage, the stem cannot grow in height except by means of lateral shoots; these will subsequently require bud-pruning once they have attained the required size. Buds which appear in undesirable places can be removed in the same manner, the ultimate result being that a tree considerably forked and supplied with abundance of foliage is obtained. The production of woody tissue in the upper part of the tree is appreciably checked, and the girth of the basal stem increases more rapidly than when the tree is allowed to grow upwards uninterrupted.

At Henaratgoda the trees which have forked at 7, 9, and 11 feet from the ground show an increase of about 30 inches in thirty years.



Photo by H. F. Macmillan.

THIRTY YEAR OLD PARA RUBBER TREE IN CEYLON.

1. FORKED TREE.
2. STRAIGHT STEMMED TREE.

or an average of one inch, per year, throughout a long and fairly reliable period. Young trees which have been bud-pruned in the manner suggested above show an increased rate of circumferential growth; this means the attainment to a tappable size at an earlier period.

WHEN PRUNING SHOULD BE TRIED.

This operation is impossible or useless on old trees which have produced high woody stems. To cut off the whole of the stem and branches above fifteen feet would check the growth of the remaining stem, and such a measure is not recommended. Old trees treated in this manner produce foliage but this mainly testifies to their hardy characteristics.

The stems of plants, when less than 20 feet in height, are more suitable for such an operation; when 12 to 15 feet high the terminal bud alone can be easily removed by thumb-nail pruning, and lateral shoots will soon appear in the axils of the leaves on the "green wood" of the stem. The object is simply to produce a forked tree, the advantages of which can be observed on any young rubber plantation. If the plants have been allowed to grow too high it is *too late* to perform the operation.

This treatment has reference only to young clearings of Para rubber, but, considering how many thousands of acres are being yearly planted with this product and the possibility of appreciably reducing the long years of waiting, it is important that it should be carefully considered and tried experimentally wherever possible.

The large acreages of rubber trees planted during the last two years will in all probability be regularly tapped as soon as they have attained the proper circumference, and it is therefore necessary to do all in one's power to help the trees on to the desired condition. Not only is it necessary to get a return as quickly as possible, but it is advisable to place the rubber on the market while the price is high, without unduly taxing the powers of the tree. The lower six feet of each tree will provide work for about 3 years' systematic and economic tapping, and the question of high tapping, as at present being carried out at Henaratgoda and elsewhere, can perhaps be dismissed.

If the young plants are made to branch too much there may be a disadvantage, as the foliage of adjacent trees may interfere. In such case, however, were it desirable, the excessive branch development could be kept down by repetitional pruning. It should be remembered that the lateral shoots, induced by pruning the terminal bud, ultimately form stout branches which tend to grow upwards and not horizontally.

EFFECT OF PRUNING PARA RUBBER TREES.

Dimensions of straight-stemmed and forked Trees in Ceylon.

District.	Age of Rubber Trees.	Average Circumference of Trees a yard from the ground.				
		Straight-stemmed Trees.		Forked Trees.		Average Difference.
		Number.	Average Girth.	Number.	Average Girth.	
	years.		Inches.		Inches.	Inch.
Galaha	7	15	21·33	7	25·14	3·81
Galaha	10	14	28·78	4	38·37	9·59
Kalutara	2	94	7·5	76	8·3	0·8
Matale	3	329	13·9	78	15·5	1·6
Kalutara	1½	14	4 to 7	32	4½ to 7½	0·4
Moneragalla	2½	250	6½	250	8½	1½
Kalutara	old	1	31	1	35	4
Do.	old	1	23½	1	29	5½
Do.	old	1	23	1	32	9
Henaratgoda	30	10	75	10	105	30

INCREASE IN GIRTH AFTER FOUR MONTHS.

The following is an account * of one experiment carried out at Peradeniya:—Two plants of exactly the same age, grown from seeds from the same parent were selected. In one case the plant was allowed to produce the usual long and slender stem; the other tree had its terminal bud removed by thumb-nail pruning, and being unable to grow in height, threw out ten lateral branches. The result was the straight-stemmed tree had only one growing point at the apex of the stem, whereas the pruned one had ten, and from each of the latter were produced whorls of foliage. The plant so treated had, four months after pruning, no less than 200 fully-developed leaves, whereas that which had been allowed to grow in its own way had only about 50 leaves. The food-producing capacity of the pruned tree, as far as the foliage alone was concerned, was four times as great as that of the straight-stemmed one, and it stands to reason that the basal part of the pruned tree would probably grow at a quicker rate. The operation itself is a gentle one and does not partake of anything so drastic as the cutting away of the upper part of young or old trees. The lateral branches each produce their own whorls of foliage as though they were members of separate trees, and as they tend to grow more or less upwards may themselves require pruning at intervals of three or six months.

It is therefore possible to lead to the production of a large number of branches and we have next to enquire how soon the effect is obvious in the girth of the stem.

The Science of Para Rubber Cultivation; Messrs. A. M. and J. Ferguson, Colombo, 1907.



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DISTANCE IN PLANTING
CLOSE PLANTING AND THINNING OUT.

The two plants referred to were over one-and-a-half year old from stumps, and the forked one showed, four months after pruning, a circumference of $4\frac{3}{4}$ inches as against 4 inches for the straight-stemmed tree; this means an increase of over half-an-inch within six months of the pruning operation.

The young trees on various estates in Ceylon and the old trees at Henaratgoda indicate that an average increase of about one inch per year may be obtained by making them fork at the proper height.

If an average increase of one inch per year can be obtained, it means that a year is gained in the first four or five years and the minimum tapping size of 20 inches may be reached in the fourth year.

An interesting series of figures obtained in the Kandy District showed that trees of the same age, which had branched at a point 12 to 14 feet above ground, had an average circumference of 19 inches, and those which had branched at 5 and 8 feet from the ground had an average of 26 inches

In the Kalutara District trees of the same age, but divided at the base into two, three, and four stems respectively, measured, in stem circumferences per tree, 14·4, 18·1, and 22 inches respectively. In all parts of the island the increased circumference due to forking of the trees can be seen, and the fact has even been noted in the annual report of a prominent Company largely interested in rubber.

The Neboda Tea Co., of Ceylon, Ltd., in their annual report for 1905, state that the two tallest trees show the smallest girth, and the shortest and well-branched trees the best

INTER AND CATCH CROPS.

Where the rubber plants are closer than 10 to 15 feet the cultivation of inter or catch crops is limited to about four to eight years. Cassava, bananas, cacao, coffee, chillies, groundnuts, lemon grass, pepper, gingelly, and perhaps tobacco and cotton, are amongst the most notable products for use under such conditions. If the intercrops are such that they can under ordinary circumstances be grown permanently—as cacao and coffee—it is better to grow them only in widely-planted rubber clearings, and to arrange them between the rubber plants so that a fair root space is available for all. Cacao and coffee are among the best products to be grown as intercrops in rubber, and are being cultivated extensively in India, Samoa, Java, Sumatra, Straits, and Ceylon as permanent intercrops. Coffee is known to grow well under shade; in parts of India it is being cultivated as an inter or catch crop in rubber clearings, where the rubber plants are planted twenty-four feet apart and the coffee six feet apart.

If real catchcrops are grown to occupy the land from 6 to 12 months at a time, care should be taken not to plant them too near the rubber plants. A radial distance of one to two feet should be allowed for the growth of the roots of the rubber trees each year, and catchcrops should not be planted within the rubber root area.

The catch crops can be planted one, two, three, and four feet from one, two, three, and four-year-old rubber trees respectively; in all cases the foliage or ashes obtained as by-products of the catch crops can be forked in around the trees or broadcasted over the areas which are partly occupied by the rubber roots

LEMON GRASS AND CITRONELLA.

Lemon grass gives a return six months after planting, and may be expected to yield about 14,000 lb. of fresh grass containing about 20 lb. of pure oil, per acre, per year when grown in open free soil. The oil is valued at 2*d.* to 8*d.* per ounce, and is obtained by steaming the freshly-cut grass. A distilling apparatus is required, and can be kept in constant use by the grass from 300 acres. The fresh lemon grass contains 0.65 per cent. of potash, 0.09 per cent. of phosphoric acid, and 0.12 per cent. of nitrogen, but if the dried distilled grass is used as fuel and the ashes for manuring the rubber plants, the exhaustion is considerably reduced. The plant is propagated from cuttings. It is being cultivated in parts of Ceylon and the Straits.

CITRONELLA.

Citronella can be cultivated and distilled in exactly the same manner as lemon grass, and may be expected to yield about 50 to 60 lb. of oil, per acre, per year; the pure oil is valued at from 1*s.* 4*d.* to 1*s.* 10*d.* per lb. in Europe and America.

GROUNDNUTS.

Groundnuts yield as a single product a crop of 1,500 to 3,000 lb. of nuts per acre in various countries, the best-yielding varieties in Ceylon being the "Mauritius" and "Barbadoes." The nuts are valued at from £8 to £14, according to size, number of seeds per nut, and cleanliness. The seeds yield a valuable oil, equal to Olive oil in quality, and the residue after extracting the oil is sold as a manure—groundnut cake—containing 7½ per cent. of nitrogen. The foliage can be used as a green manure or cattle food, and is known as pea-nut hay in America. The leaves and roots contain nearly 1 per cent. of nitrogen, and when mixed with lime form a good plant food for the young rubber trees. The plants are propagated from seeds. The crop ripens in 4 to 6 months, very little machinery is required, and there is a good demand for the oil and cake.



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PARA RUBBER AND CATCH CROPS.
YOUNG PARA RUBBER AND CASSAVA.

CASSAVA OR TAPIOCA.

There are several famous Para rubber plantations in Malaya which have practically paid for all working expenses by cultivating varieties of *cassava* as catch crops for the first three or four years. On one plantation the rubber was planted 15 by 15 feet and the *cassava* 6 feet apart at the same time as the rubber. The crop was ready for harvesting in 18 months from planting. A second crop was taken off the land before the end of the fourth year, after which the *cassava* cultivation ceased to be profitable. I have been informed that a crop of tapioca or *cassava* flour of $1\frac{1}{2}$ to 2 tons per acre, per crop, is thus obtainable. The proceeds from these crops have on several estates more than paid for the upkeep of the rubber. On one estate in Malaya *cassava* or tapioca is largely cultivated, and on one field, from which very good crops of this product have been taken, the six-year-old Para rubber trees have an average circumference of 20·21 inches, the largest measuring 33 inches and the smallest 13 inches in girth at a yard from the ground.

Cassava thrives best in good soils and can, according to Lewis,*—be grown in districts in Ceylon with only 14 inches of rainfall per year or in districts with over 100 inches per year. The plant is propagated from the stem, which is cut into pieces about twelve inches in length, each being planted in a mamoty hole at distances of 3 to 8 feet. The yield in Ceylon is said to be from 8 to 10 tons of tubers per acre, or from 40 to 80 lb. per plant. The cuttings should be planted in wet weather; once established they continue to grow even during periods of severe drought.

The exhaustion following the cultivation of *cassava* can be partly overcome by the application of manure: the growing crops would for the first three years protect the soil and thus mitigate the loss which invariably accompanies the exposure of the surface to sun and rain.

On several estates owing to the *cassava* having been planted too near the rubber saplings a considerable amount of harm has been done; the growth of the rubber trees should not, however, be very seriously interfered with if proper distances are adopted.

COTTON.

The Para rubber growing districts in Ceylon usually have a rainfall far in excess of that required for cotton, but in other countries where rain falls only during certain months and where a drought can be relied upon, the prospects for cotton as a catch crop in rubber are somewhat favourable. Rain is required during the

* Manico, by J. P. Lewis, Government Agent, Northern Province, Ceylon.

first two or three months after planting, and irrigation may or may not be required subsequently. The ground should be lined in rows five feet apart and the seeds sown at distances of 18 to 20 inches apart in the rows, 6 lb. of seed usually being sufficient for one acre. Selection of seed is necessary to prevent deterioration from year to year. Plants sown in September-October may flower in January, and the first crop may be picked about six weeks after flowering. According to Mee and Willis* about 80,000 polls give 100 lb. of lint and 200 lb. of seed.

Para rubber and cotton are being tried experimentally in the dry Northern Province of Ceylon. The land at the Experiment Station in that part of the island is relatively flat and can be irrigated. In one experiment Mr. Mee planted the rubber trees 20 feet apart with irrigation channels running midway between the trees so that each Para rubber tree had an irrigation channel running down, 10 feet on either side of it. The cotton was planted 5 feet apart between the rows of rubber, and in the first year there might be three, in the second year two, and in the third year one, row of cotton between adjacent lines of rubber trees. On an experimental plot planted on this system, the Para rubber trees planted in October 1904, and at intervals up till April 1905, showed in September, 1906, a height of 8 to 15 feet and a girth of from 3 to 6 inches; the growth is very satisfactory for a dry, irrigated district.

CHILLIES.

These are not cultivated extensively as a catch crop by Europeans in Ceylon, though the successful results obtained in India and the West Indies appear to warrant full consideration. The plant is propagated from seed, the latter being put in well-prepared nurseries until a favourable opportunity occurs to plant. In Ceylon the planting generally begins in April and picking commences in June, and continues for five or six months. According to Drieberg, a chillie plant, with proper attention lives for a year; the produce per plant varies from 10 to 20 fruits and upwards per picking, and two or more pickings can be got; he further states that in Colombo the ordinary market price of fresh chillies may be put down at 12 cents per 100 and dry imported ones at 15 cents per pound of about 750 chillies. The chillies require to be thoroughly dried or cured before being despatched to the market.

TOBACCO.

Tobacco as a catch crop under rubber has not been largely cultivated either in Ceylon or Malaya, mainly owing to the atmosphere being too moist. It is largely grown under rubber in Sumatra and

* Cotton, Circular Vol. 111., No. 18, R.B.G., Peradeniya.



Photo by Ivor Etherington.

PARA RUBBER AND TEA : BOTH IN BEARING.
NIKAKOTUA ESTATE, MATALE, CEYLON.

on a few estates in Java and Borneo. The time taken from transplanting to harvesting varies from about 70 to 100 days; and dry weather is necessary towards the beginning of harvesting time. It may yet be possible to cultivate either the "wrapping," "binding," or "filling" types of leaves during certain seasons in parts of Ceylon.

The cultivation of tobacco requires very careful selection of varieties and climate and frequently one finds that it is only possible to grow one variety in a particular local area. The methods of cultivation depend upon the variety being grown, but in nearly all cases the plants are first reared in a nursery made to hold from 1,500 to 2,000 seedlings and subsequently transplanted. The seedlings are planted out, in moist weather, when about five to seven weeks old, and are distanced according to requirements, those for Sumatra wrappers usually being close together. When the plants are 1 to 1½ feet high the basal leaves are removed and the earth heaped up around the plants; at a later stage the flower buds are pinched off, and all suckers are removed as soon as they appear. The leaves are ready for harvesting when the plant acquires a yellowish colour; sometimes the whole plant is cut, but in Sumatra the leaves on each plant are plucked separately when ripe. The leaves are then carefully sorted, cured, tied in bundles and packed. In some countries this cultivation is very profitable but requires very careful supervision at all stages and a large working capital.

CAMPHOR.

The desirability of growing camphor as a catch or intercrop has often been discussed, but so far very few rubber planters in the East have given the subject much attention. The plants can be planted out on lines very similar to those adopted with coffee; a crop of pruned leaves and twigs cannot be expected before two years at least, and a distillation plant of a simple type, is required.

The profitable cultivation of catch crops is limited to about the first four years, as the products grown cannot be planted close to the Para rubber trees, and at the end of the fifth year would be almost limited to the middle of the lines. Furthermore, they are all very exhausting.

FUTURE OF INTERCROPS.

The successful and continued cultivation of intercrops with Para rubber mainly depends on the distance the plants are from one another. The rapidly-growing surface roots of Para rubber will ultimately take possession of the soil, and the intercrops of tea, cacao, or coffee cannot be expected to thrive except the rubber plants are widely planted. I have seen several examples of 14-year-old tea planted with 6-year-old Para rubber, the latter 15 by 10 feet

apart : the tea presented a very weak, spindly appearance and could not be profitably plucked. The cultivation of tea under closely-planted rubber is more or less of a catch crop, but several estates are known where the rubber is widely planted amongst tea and both are bearing and doing well. The two products are very frequently grown together in Ceylon—especially in the low-country and in parts of Matale, Kegalla and the Uva Province up to 2,600 feet, and in South India up to 3,500 feet. The illustrations given elsewhere show properties in Ceylon where tea and rubber are growing together.

Cacao and coffee planted in the middle of the lines will last for several years under rubber. The roots of these plants do not as closely ramify the soil as those of the crowded tea plants, though they will ultimately have to face the struggle for existence with the roots of Para rubber and will probably be choked out. Cacao may be planted 10 to 20 feet apart, and the amount of soil on good cacao estates which is free from roots is often very large and permits of the growth of other trees on the same acreage. Cacao under rubber will last much longer than tea, and the protection of the Para rubber trees against excessive exposure is no doubt greatly in favour of the two products being grown together. In the Matale, Dumbura, Kurunegala, Polgahawela, and in Kandy Districts of Ceylon, cacao and Para rubber as a mixed cultivation is extending. Good results have been obtained on Kepitigalla, Dangan, Wariapolla and many other estates in Matale and on numerous private and public properties in the above-mentioned districts. The planting of both products on the same soil is done in such a way as to allow free root areas for both species during the first five years, many planting the cacao and rubber both twenty feet apart so that there will be approximately 100 rubber and 100 cacao trees per acre. Though the rubber ultimately becomes the stronger component, it is surprising how long both products can be successfully grown together. In the cultivation of intercrops under Para rubber it is essential that both products be planted at the same time, as the Para rubber tree is about as strong as the coconut palm in its root system and quickly takes possession of the soil. The illustrations which have been given elsewhere, showing Para rubber in association with cacao and tea in Ceylon and with coffee in South India, could be considerably increased, but they are sufficient for the purpose and are worthy of careful study by all rubber planters. Apart from the question of having more than one product to rely on, it is often better, for plant sanitation reasons alone, to have mixed plantations; plants of different genera grown together are often helpful to one another.

The cultivation of pepper among rubber necessitates permanent stumps, preferably of the Dadap plant.



Photo by F. J. Holloway.

PARA RUBBER AND COCOA.
KEPITIGALLA, MATALE, CEYLON.

CHAPTER V.

PARA RUBBER SOILS AND MANURING.

The mechanical and chemical composition of rubber soils—Peradeniya Henaratgoda—Udugama—The soils and rubber planting in various parts of Ceylon—Carruthers and Bamber on rubber land and soils in the Federated Malay States—Typical soils of Malay States—Chemical and physical analyses of soils in the Federated Malay States by Bamber—Cabooky, alluvial, and swampy soils in Ceylon—Treatment of swampy soils—Illustrations showing Para rubber on Passara Group estate, Passara; young and old rubber on Madampe estate, Rakwana, Arampola estate, Kurunegala; Para rubber and tea on Nikakotua estate, Matale; Para rubber on Hunugalla estate, Kegalla—The Kelani, Kegalla, Kalutara, Galle, Matale, Pussellawa, Ratnapura, Ambagamuwa, Kurunegala, and Passara Districts—Analyses of soils in the West Indies and America—Demerara, Grenada, St. Vincent, Trinidad, Nicaragua and Surinam—Principles of Rubber Manuring—Manuring to increase the latex—Forest vegetation and Para rubber trees—Manuring old and young trees—Objection to destroying rootlets—Artificial Manures for rubber soils—How to apply readily soluble and stable manures—Forking, trenching, and root growth—Results of manurial experiments—Effect of nitrogen and potash—Illustration showing trench-manuring for young rubber—Constituents in woody stem, twigs, fresh, and dried leaves—Composition of artificial manures obtainable locally—Green manuring for Para rubber trees—Limit 6 to 8 years—Suitable herbaceous plants and their composition—Illustration showing young Para rubber and *Crotalaria striata*—Tree forms, Dadaps and Albizzias—Organic matter obtainable—Green manuring in Malaya.

IT has been conclusively shown that Para rubber trees can be grown in soils relatively poor in physical and chemical properties, and the following analyses of soils in different parts of Ceylon* will

* Circular of the R. B. G., Peradeniya, by Herbert Wright and A. Bruce, Vol. III., No. 6, July, 1905.

PARA RUBBER.

illustrate the composition of those which have given good results with Para rubber :—

	Peradeniya		Rubber Soils at Henaratgoda.	
	Soils.		1	2
	Mechanical	Udagama	Soil under	Soil from
	Composition.	Swamps.	Old Rubber.	Pasture Land.
	Per cent.	Per cent.	Per cent.	Per cent.
Fine soil passing 90 mesh ..	27·00	59·00	20·00	26·00
Fine soil passing 60 mesh ..	20·00	36·00	28·00	28·00
Medium soil passing 30 mesh..	9·00	1·00	14·00	21·00
Coarse sand and small stones..	44·00	4·00	38·00	25·00
	100·00	100·00	100·00	100·00
Chemical Composition No. 81				
Moisture ..	4·000	5·600	1·200	1·600
Organic matter & combined water	9·200	20·400	7·800	7·000
Oxide of iron and manganese..	8·400	1·200	2·800	2·000
Oxide of alumina ..	12·215	5·232	4·960	6·315
Lime ..	0·060	0·050	0·040	0·060
Magnesia ..	0·086	0·115	0·057	0·072
Potash ..	0·092	0·061	0·046	0·038
Phosphoric acid ..	0·038	0·064	0·031	0·031
Soda ..	0·095	0·182	0·046	0·080
Sulphuric acid ..	Trace	0·048	0·007	Trace
Chlorine ..	0·014	0·048	0·004	0·004
Sand and silicates ..	65·800	67·000	83·000	82·800
	100·000	100·000	100·000	100·000
Containing Nitrogen ..	0·134	0·448	0·154	0·134
Equal to Ammonia ..	0·163	0·544	0·187	0·163
Lower oxide of iron ..	Nil	Much	Trace	Fair
Acidity ..	Faint	Much	Much	Much
Citric soluble potash ..	0·006	0·009	0·005	0·004
Citric soluble phosphoric acid	Trace	Nil	Trace	Trace

PARA RUBBER SOILS IN CEYLON

The extension of Para rubber cultivation in various parts of Ceylon is, in a general way, an indication of the suitability of the soil and climate for this product; it is therefore of importance to dwell upon the soil characteristics in some of the more promising districts, though these points should be considered in conjunction with the climatic factors for the same areas.

The large tracts of land in the up-country districts which are richest from a chemical standpoint cannot be included in the Para zone of the island on account of unfavourable climatic conditions. The following notes and analyses of Ceylon soils are largely taken from a circular* dealing with this subject.

* R. B. G. Circular on Para Rubber in Ceylon, No. 6 1905.



Photo by M. Kelaway Bamber.

PARA RUBBER IN CEYLON
KALUTARA DISTRICT.
YOUNG PARA RUBBER IN DRAINED SWAMPY LAND.

The soils in which rubber is cultivated in Ceylon are relatively poor from a chemical standpoint. The organic matter and combined water vary from about 2 to 20 per cent., the potash from 0.03 to 0.04 per cent., phosphoric acid from 0.01 to 0.1 per cent., and the nitrogen from 0.1 to 0.5 per cent. But, it has been proved beyond doubt that the physical and climatic characteristics often outweigh any advantages of richness in chemical properties.

PARA RUBBER LAND & SOILS IN THE FEDERATED MALAY STATES.

I am indebted to Mr. J. B. Carruthers for much information regarding the land and soil in various parts of the Federated Malay States. The rocks from which most of the non-alluvial soils are formed are limestones, sandstones, laterites, and granites, the disintegration products of red laterite being considered good. The low-lying land at the foot of the mountain range is composed of a deep alluvial deposit; the subsoil in such areas is said to be far below the water-level, and for purposes of cultivation may therefore be neglected. The majority of the alluvial land, planted in Para rubber, is, if anything, too well supplied with water, the latter being within 3 to 4 feet from the surface all the year round; the water-level all over the plains on the west of the mountain range is, according to Carruthers, very near the surface—often as near as 16 to 18 inches.

Mr. M. Kelway Bamber, who recently toured through the Federated Malay States and visited several of the leading Para rubber properties, is convinced of the richness of many of the soils and the suitability of large areas for the cultivation of *Hevea brasiliensis*. The physical composition of the soils is often remarkably good, and on Mr. Bamber's authority it can be stated that some of the samples pass, almost entirely, through a sieve of 8,100 meshes to the inch. The organic matter frequently exceeds 30 per cent., and the nitrogen is sometimes as high as 0.9 per cent. These high percentages are not, however, obtainable over all estates in the Federated Malay States. Many of the Ceylon soils are quite as good as, and occasionally superior from a chemical standpoint to, those in the Federated Malay States, but in only a few low-country soils in Ceylon does the organic matter reach 20 per cent. In relation to Ceylon soils the mineral contents of the Federated Malay States soils are very often inferior, the chief deficiency being potash, rather than phosphoric acid.

TYPICAL SOILS OF MALAY STATES.

Mr. Bamber, in a report published by Mr. J. B. Carruthers, stated that "the soils of Malaya may be roughly divided into two distinct kinds.

(a) The flat alluvial clays or muds on the banks of rivers and near the sea coast.

(b) The undulating low soils a few miles inland, where they vary from free sandy loams to heavy clays.

“Peaty soils on clay usually lying a few miles from the coast. The alluvial clays or muds are in an exceedingly fine state of division, about 96 per cent. passing through a mesh of 8,100 per square inch, and the balance through a mesh of 3,600 per square inch. Although having the appearance of fine clays there is very little alumina present, the bulk of the soil being composed of very finely-divided sand and insoluble silicates. When wet they are compact and greasy, but on drying they break up into comparatively free loams, through which roots can permeate freely, so that, unless liable to flooding with salt water, they are all well suited for the growth of Para rubber, coconuts, and Liberian coffee. The amount of organic matter in these soils varies considerably—from 8 to 35 per cent., or even more if the surface layer is at all peaty. They are generally very rich in nitrogen, containing from 0·4 to 0·9 per cent. on the air-dried soil; a soil with 0·2 per cent. being considered rich in other countries.

“With regard to the mineral matter, which forms the ash of the plants, they are not so rich; although the exceedingly fine state of division of the soils renders a high proportion less necessary. They are more or less deficient in lime, which accounts for the markedly acid character of the soils when first opened; the acidity is neutralized to some extent by ash from the burnt forest, but it also gradually diminishes as the drainage water is removed to a lower level and the soil becomes aerated. Magnesia is present in ample quantity in most cases. Potash, one of the chief mineral constituents required for plant growth, is frequently deficient, though a few of the river deposits are rich in this constituent, and the subsoil is usually richer than the surface soil especially if of a clayey nature. The proportion of phosphoric acid is also variable, ranging from 0·12 to 0·13, the average being about 0·76 per cent. on the air-dried soil. All this class of soil requires very efficient drainage as it has often been more or less under water for years, so that air has been excluded, resulting in a rather high proportion of the lower oxide of iron, which in excess is poisonous to many cultivated plants. The vigorous growth of rubber on this class of soil after drainage is unequalled elsewhere during the first years of growth.

“They are richer in nitrogen than the proportion of organic matter would indicate, but are usually a little deficient in total potash and to some extent in phosphoric acid.

“Their free character and suitability for root growth makes the proportion of the set constituents ample for present requirements, and it is evident from the growth of Para on these soils that there is no deficiency in any respect.”



Photo lent by the Kegalle Planters' Association.

PARA RUBBER AND TEA IN BEARING.

UNDUGODA ESTATE, KEGALLE.

The following analyses were also given by Mr. Bamber:—

CHEMICAL AND PHYSICAL ANALYSIS OF FEDERATED
MALAY STATES SOILS.

MECHANICAL COMPOSITION.

	Mechanical Composition.					
	Alluvial Clays.			Sandy Loams.		
	Subsoil					
	%	%	%	%	%	%
Fine soil passing 90 mesh ...	96·00	95·50	68·00	30·00	36·00	26·00
" 60 "	4·00	4·50	32·00	34·00	38·00	30·00
Medium soil passing 30 mesh	...	...	...	26·00	8·00	22·00
Coarse sand and small stones	...	...	...	10·00	18·00	22·00
	100·00	100·00	100·00	100·00	100·00	100·00

CHEMICAL COMPOSITION.

Moisture ...	6·920	5·560	5·000	1·400	4·000	2·200
Organic matter and combined water ...	24·080	16·640	8·000	3·000	9·600	5·600
Oxide of iron and manganese	1·120	1·200	3·000	0·300	8·240	0·700
" " alumina	2·971	3·019	2·520	1·165	4·183	2·516
Lime ...	0·284	0·200	0·160	0·140	0·160	0·160
Magnesia ...	0·252	0·381	0·230	0·130	0·100	0·130
Potash ...	0·131	0·169	0·014	0·014	0·053	0·030
Phosphoric acid ...	0·025	0·012	0·076	0·051	0·064	0·064
Sand and silicates	64·200	72·800	81·000	93·800	73·600	88·600
Chlorine ...	0·017	0·019				
	100·000	100·000	100·000	100·000	100·000	100·000
Containing nitrogen ...	0·667	0·425	0·403	0·492	0·386	0·403
Equal to ammonia ...	0·810	0·516	0·489	0·598	0·469	0·489
Lower oxide of iron ...	Much	Fair	Good	Good	Good	Good
Acidity. ...	..	...	Marked	Marked	Marked	Marked

CABOOKY, ALLUVIAL, AND SWAMPY SOILS, CEYLON.

"Cabook.—The cabook soils are met with as local areas in many districts. They are usually inferior from a chemical and physical standpoint, though in many cases the growth of the rubber trees appears to be satisfactory. Such soils usually show a small percentage of organic matter, potash, phosphoric acid, and lime.

"One analysis shows only 8 per cent. of organic matter and combined water, 0·085 per cent. of potash, 0·010 per cent. of phosphoric acid, 0·060 per cent. of lime, and 0·128 per cent. of nitrogen."

"Alluvial soil.—In physical properties these soils are usually good, and the amount of sediment periodically deposited during floods adds considerably to the chemical richness of the soil.

“They are largely composed of the lighter materials carried down in suspension by moving water. The particles are very fine, most of them passing a 60 mesh.

“The particles are arrested and precipitated all along the bank of the river during flood time. During heavy floods very large quantities of matter are often deposited along the banks, but they are often of a coarser nature due to the higher speed.

“The particles which go to make up an alluvial soil may have been brought from considerable distances; they constitute the fine parts of soils liable to wash within the drainage area of the river.”

One analysis shows about 11 per cent. of organic matter and combined water, 0.130 per cent. of lime, 0.162 per cent. of potash, 0.076 per cent. of phosphoric acid, and 0.230 per cent. of nitrogen. The soils are usually good, and we know that Para rubber grows exceedingly well in such soils and continues to thrive therein for over twenty years in the Peradeniya District.

“*Swamps*.—The cultivation of rubber in such areas has, during the last year or so, shown a considerable increase. Providing the draining and liming of the soils are efficiently carried out, there seems no reason why continued satisfactory growth should not be obtained on such land.

“The drainage should be very thorough, so as to allow of a good percolation of air and water through the otherwise sour soils.

“In some cases each rubber tree should have a separate drainage system, the drains being two or more feet wide and 3 to 4 feet deep, the material from them being heaped up near the rubber tree. In other cases each line of rubber trees may be separately drained. When the drains are sufficiently large and the soil from them is heaped around the rubber, a dry soil is ultimately obtained in areas which have hitherto been too swampy for any cultivation except paddy.”

One analysis shows the soil to contain 20.4 per cent. of organic matter and combined water, 0.05 per cent. of lime, 0.061 per cent. of potash, 0.064 per cent. of phosphoric acid, and 0.448 per cent. of nitrogen.

Such an analysis indicates a chemical richness in organic matter and nitrogen which rarely obtains in low-country districts, and strongly reminds one of the soils at high elevations in Ceylon. It is to be regretted that the area of such rich land in the low-country is small, and the above analysis is certainly encouraging to planters who have such swampy soils capable of being effectively drained and made sweet by the application of lime or by burning.

TREATMENT OF SWAMPY SOILS.

In the Straits Settlements and Federated Malay States and in parts of Ceylon drained swamps have been proved to grow Para rubber; in the former place large sums of money have been



Photo by D. L. Goonewardene.

MATURE RUBBER IN AMBALANGODA

TAPPING 11-YEAR OLD TREES. DEVITURAI ESTATE, ELPITIYA, CEYLON.

spent in providing good canals for the free circulation of water through rubber estates near the coast.

“Swampy soils are usually in a very fine state of division, a condition which may prevent the soil being aerated, and to some extent may hinder the free oxidation of the humus. Owing to the extremely fine state of division the soil can retain large quantities of water, due to the particles being in such close contact with one another that they form a very large number of capillary tubes which become full of water. Again, such a soil may suffer during periods of drought, as it is difficult to get the air out of the capillaries. A water-logged soil is usually cold and therefore generally unsuitable for cultivation, unless it can be modified both physically and chemically. One of the chief aims in reclaiming such land is to have the soil well drained, in order that the superfluous water may be carried off and the air drawn through the soil.

“Burning has been tried on peaty soils at high elevations, and the results are satisfactory. Paring the surface and collecting into heaps and then burning has also proved successful. The heat should not be allowed to become too great and should just be sufficient to char the vegetable organic matter; the heaps should then be distributed over the surface. There is a loss of nitrogen and organic matter, but the physical condition of the soil is improved, and the potash salts are converted into carbonates which are useful for the neutralization of the free acids present. After burning, the potash, &c., is in a much more available condition.

“Opening up of swampy soil by the addition of sand or gravel has been tried, but this is expensive. Liming is very beneficial for such soils, as it not only opens them up but also neutralizes the free acids present, and thus gives a freer action to nitrifying organisms. The addition of lime frees the potash from the double salts by double decomposition, and makes the mineral plant food generally more available. Swampy soils are usually deficient in mineral plant food, and should have occasional dressings of potash and phosphatic manures, basic slag, and sulphate of potash or kainit being considered suitable.”

PARA RUBBER SOILS IN VARIOUS DISTRICTS IN CEYLON.

In order to give some idea of the composition of the soils of typical rubber districts in Ceylon, it is necessary to draw inferences from many analyses. The districts known as Kelani, Kalutara, Kegalla, Matale, Peradeniya, Kurunegala, Ratnapura and Passara are of considerable importance, and the information given in the Circular previously referred to is here quoted.

KELANI VALLEY DISTRICT.

According to the report of the District Planters' Association, for the year 1905, it was estimated that there were about 14,000 acres planted in rubber alone in addition to a large acreage

interplanted with tea. The abundant rainfall and high temperature together with the moderately good soils in the Kelani district seem very suitable for *Hevea brasiliensis*.

“*Mechanical characters.*—The mechanical composition of the soil is moderately good; generally 14 to 35 per cent. passes through a 90 mesh, 20 to 40 per cent. through a 60 mesh, and 3 to 8 per cent. through a 30 mesh; sand and small stones constitute 30 to 60 per cent. on an average. The plants are mainly dependent upon the finely-divided soil particles for their food supplies, and therefore the amount which passes through the 90 mesh is of the greatest importance. Some soils which are very finely divided are not so well suited for cultivation as coarser types, the latter frequently allowing of a quicker, and more complete circulation of air and water in the soil. The retentive power of moisture of the soils depends upon the physical properties and the amount of organic matter present. This variation for the Kelani soils is from 2 to 6 per cent.: *i.e.*, every 100 lb. of air-dried or sun-dried soil can retain from 2 to 6 lb. of water.”

“*Chemical properties.*—The percentage of chemical ingredients is, relatively speaking, rather low when compared with soils at higher elevations. In some cases the percentages of organic matter and nitrogen are satisfactory. The organic matter varies from 8 to 13 per cent.; the nitrogen from 0.05 to 0.2 per cent.; the lime from 0.05 to 0.15 per cent.; the magnesia from 0.05 to 0.35 per cent.; potash from 0.05 to 0.2 per cent.; and the phosphoric acid from traces to 0.07 per cent. In some cases the high percentages of organic matter and potash are exceptional, and do not represent the general characters in the Kelani District. The figures here quoted indicate the general variation in the proportions of the ingredients which may be expected in the district; they do not represent the maximum and minimum compositions.”

KEGALLA DISTRICT.

The Kegalla District might also be considered in connection with the Kelani, as the soil and climate appear equally suitable for Para rubber. According to the 1905 report of the District Association, the Kegalla planters then had over 6,500 acres of rubber, either alone or interplanted with tea. Good growth has been obtained in clearings only 10 and 18 months old on the Mabopitiya, Dickellia, Waharaka, Parambe and other estates in this district, and the tapping of trees from 12 years upwards on Yataderiya and Undugoda estates has been accompanied by profitable yields. On many of the estates in the Kegalla district, the Para rubber is interplanted among tea; the illustration elsewhere shows both products doing well on Undugoda Estate, Kegalla. Elsewhere illustrations are given showing trees only 32 months old on Hunugalla estate, and tapping of mature trees on the property of the Yataderiya Tea Co., all in the Kegalla district.



Lent by MacLaren & Sons.

PARA RUBBER TREES ALONG RIVER BANKS, CEYLON.

KALUTARA DISTRICT.

During the year 1905 the acreage under Para rubber in the Kalutara District was largely increased. The report of the District Association for 1905 showed 6,038 acres in rubber alone, and 7,256 in rubber planted through tea, making a total of 13,394 against the figures (for 1904) of 3,128 acres in rubber alone and 6,759 planted through tea. It is obvious that during 1906 a considerably larger acreage of new land was planted, but it is not thought that very much more tea will be planted up with rubber. In addition to the above, large acreages are being planted by European and native proprietary planters in the district.

Several illustrations are given showing the growth of Para rubber trees in various parts of the Kalutara District, some of them in the young stages, others mature and now being tapped.

South of Kalutara, in the Galle District, soils of similar character are met with and swamps frequently occur. According to the report for 1905, no less than 2,500 acres were then in Para rubber and other 2,500 acres were estimated for 1906.

Mechanical Composition.—"The soil analyses show a slightly coarser texture than those examined from the Kelani; usually from 11 to 28 per cent. passes through the 90 mesh, 16 to 40 per cent. through the 60 mesh, 4 to 10 per cent. through the 30 mesh, and sand and small stones form from 30 to 70 per cent. of the soil. The retentive power of moisture is very similar to the Kelani, varying from 2 to 6 per cent."

Chemical Composition.—"The organic matter shows a variation similar to that in the Kelani Valley soils; the general range is from 7 to 15 per cent., and the same can be said about the nitrogen, which varies from 0.1 to 0.15 per cent. This is of course excluding swampy areas, which we have seen to be very rich in organic matter and nitrogen, and alluvial soil such as that quoted below. The potash varies from 0.04 to 0.2 per cent. and usually shows a relation to the amount of magnesia, both being derived from the decomposition of double silicates. The phosphoric acid varies from a trace to 0.06 per cent., and this low percentage is common in most Ceylon soils. The lime varies from 0.03 to 0.15 per cent. and the magnesia from 0.04 to 0.2 per cent."

MATALE DISTRICT.

It is almost impossible to give the acreages under rubber in the Matale District, but as far as can be gathered there were about 1,359 acres of cacao interplanted with rubber, and 539 acres in rubber alone in 1905. The accompanying illustration shows Para rubber growing on Dangan estate, the property of the Rubber Plantations, Ltd., where the rubber and cacao trees were

about 5½ years old both being in bearing. Another photograph shows Para rubber in association with tea, both in bearing and doing well, on Nikakotua estate in the same district.

It is well known that the Matale District contains some very old Para rubber trees, now being tapped, and that large areas have been planted in association with cacao and tea as well as a single product. Trees at an elevation of 2,300 feet are now being tapped in that district.

“The soils characterising the Matale District are somewhat similar to those near Peradeniya.

Mechanical Composition.—“The soils from the Matale District are on an average in a better state of division than those in the districts previously dealt with, usually from 15 to 30 per cent. passing through a 90 mesh, 14 to 25 per cent. through a 60 mesh, and 3 to 7 through a 30 mesh. Sand and small stones may form from 40 to 60 per cent. of the soil. The retentive power for moisture of air-dried soil does not show a very great variation, and is from 3 to 6 per cent.

Chemical Composition.—“The organic matter usually varies from 8 to 14 per cent. and the nitrogen from 0·1 to 0·2 per cent.; the lime from 0·08 to 0·2 per cent.; the magnesia from 0·05 to 0·25 per cent.; the potash from 0·03 to 0·25 per cent., and the phosphoric acid from 0·01 to 0·1 per cent.”

PUSSELLAWA DISTRICT.

In the Pussellawa District the soil and climate appear to resemble those in sections of the Peradeniya and Matale Districts, and although part of the district is considered to be too high for Para rubber, there were, early in 1906, nearly 2,700 acres of this product planted alone or with tea.

RATNAPURA, SABARAGAMUWA AND AMBAGAMUWA.

The Ratnapura District, differing so widely from the foregoing in having such a heavy rainfall and being one already extensively cultivated in rubber, is here synoptically dealt with.

Regarding the mechanical composition, “out of about a dozen soils 17 to 20 per cent. of the soil passes a 90 mesh, 16 to 25 per cent. a 60 mesh, and 4 to 5 per cent. a 30 mesh, and sand and small stones account for from 50 to 60 per cent. The retentive power of moisture varies from 3 to 5. The chemical composition shows from 10 to 12 per cent. of organic matter, 0·1 to 0·2 per cent. of nitrogen, 0·06 to 0·2 per cent. of lime, 0·07 to 0·15 per cent. of magnesia, 0·04 to 0·1 of potash, and from 0·03 to 0·8 per cent. of phosphoric acid.” Para rubber is being extensively planted in this and the surrounding districts.



Photo by Colombo Apothecaries Co.

Lent by M. Scowen.

PARA RUBBER IN CEYLON.

MATURE RUBBER AND TEA; HOLTON ESTATE, WATTEGAMA.

TAPPING 15 YEAR-OLD TREES.

According to information supplied by the Secretary of the Sabaragamuwa Planters' Association, the acreage of tea inter-planted with rubber early in 1906 was 4,477—in rubber alone 1,743 acres—and during the past two years several large tracts of land have been cleared and planted with Para rubber. The photographs, showing the growth of Para rubber at Madampe, Rakwana, are all the more interesting as indicating the possibilities in this district.

The illustrations show the growth obtainable in the Rakwana District, where the elevation above sea-level varies from 700 to 900 feet, and the rainfall from 95 to 110 inches. One figure shows a rubber clearing planted from stumps in June, 1904, the plants being 17 months old at the time the photograph was taken, and varying in height between 12 to 20 feet. Another figure shows trees which have been obtained by planting two-year-old stumps in 1899, the trees being about six years old at the time the photograph was taken.

In the Upper Ambagamuwa District, where the rainfall is very heavy, Para rubber trees are being tapped and planting operations continued, though the elevation in such a wet district is thought by many to be near the maximum. About 800 acres were planted early in 1906, and some of the plants now show satisfactory growth

KURUNEGALA DISTRICT.

The rainfall of 75 to 100 inches is evidently suitable, and a general glance at the average composition of the soils would not be out of place here. The soils vary greatly, as can be seen from the following figures :—

<i>Mechanical Composition.</i>			Per cent.
Fine soil passing 90 mesh	..	..	17 to 35
Fine soil passing 60 mesh	..	..	20 to 35
Medium soil passing 30 mesh	..	..	5 to 9
<i>Chemical Composition.</i>			Per cent.
Coarse sand and small stones	..	..	20 to 60
Moisture	..	..	3 to 7
Organic matter and combined water	..	..	4 to 8
Lime	..	..	0.1 to 0.35
Magnesia	..	..	0.1 to 0.45
Potash	..	..	0.08 to 0.18
Phosphoric acid	..	..	0.02 to 0.04
Nitrogen	..	..	0.08 to 0.11

During 1905 Para rubber has been largely planted, and a total estimate of about 4,000 acres for the year 1906 was considered to be below the probable area for this district.

PASSARA DISTRICT.

According to the Passara District Association, in their report for 1905, large areas in Moneragalla and the lower elevations of Madulsima and Passara were planted in rubber during the year, and it was estimated that over 11,000 additional acres would be opened within a short time. The results from the older trees being tapped at all elevations up to nearly 3,000 feet are satisfactory. In the Uva Province the climatic conditions are said to be such as to allow of the cultivation of Para rubber up to an elevation of 2,900 feet. The illustrations given elsewhere show Para rubber at an elevation of 2,600 feet on Passara Group Estate, Passara, where trees varying in age from 7 to 13 years have given 2 lb. of rubber each during 1905.

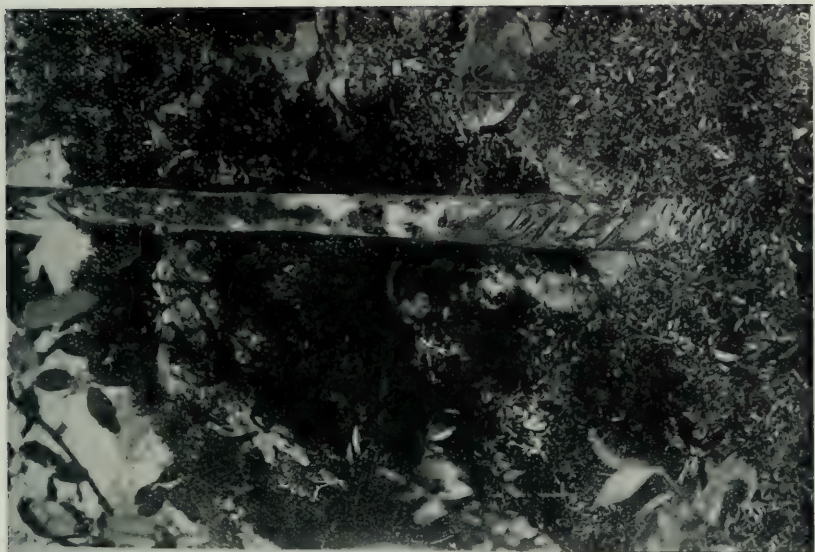
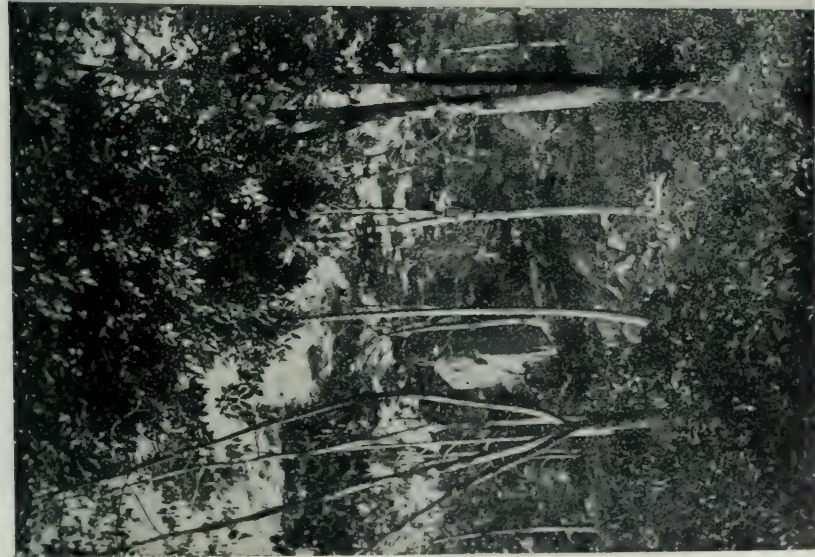
“Very few soils have been analysed from the Province of Uva, but from those obtained from Passara the following information has been compiled. Usually from 17 to 30 per cent. passes the 90 mesh, 20 to 30 per cent. the 60 mesh, 7 to 8 per cent. the 30 mesh, and sand and small stones form from 40 to 43 per cent. The retentive power of moisture is about $2\frac{1}{2}$. The chemical analyses show the presence of from 7 to 11 per cent. of organic matter, 0.1 to 0.15 per cent. of nitrogen, 0.06 to 0.1 per cent. of lime, 0.07 to 0.13 per cent. of magnesia, 0.05 to 0.08 per cent. of potash, and from 0.03 to 0.04 per cent. of phosphoric acid.”

SOILS IN THE WEST INDIES AND AMERICA.

According to Hart, the following are types of good and inferior cacao soils as determined in the Government Laboratory, British Guiana; they should be well suited for Para rubber:—

GOOD CACAO SOILS.

	Deme- rara.	Gro- nada.	St. Vincent.	Tri- nidad.	Nicara- gua.	Suri- nam.
Organic matter and com- bined water ...	9.031	10.442	3.046	3.768	10.815	15.452
Phosphoric anhydride ...	0.087	0.184	0.114	0.084	0.293	0.139
Sulphuric anhydride ...	0.018	traces	0.055	traces	0.141	0.047
Chlorine ...	traces	nil	traces	nil	0.007	traces
Iron peroxide ...	4.783	9.485	9.574	3.910	7.000	5.952
Alumina ...	9.217	10.024	8.889	2.038	4.717	16.076
Manganese oxide ...	0.347	0.313	0.435	0.127	0.163	nil
Calcium oxide ...	0.596	2.379	4.981	0.356	2.250	0.495
Calcium carbonate ...	0.032	0.026	nil	nil	nil	nil
Magnesium oxide ...	0.404	3.367	2.418	0.495	0.217	1.071
Potassium oxide ...	0.291	0.343	0.178	0.118	0.619	0.072
Sodium oxide ...	0.208	0.574	0.369	0.278	1.184	0.258
Insoluble silica & silicates	74.986	62.863	69.941	88.826	72.594	59.438
	100.000	100.000	100.000	100.000	100.000	100.000
1. Containing nitrogen ...	0.262	0.271	0.205	0.100	0.228	0.306
Water retained by air-dried soil ...	6.5	12.4	8.1	1.8	8.0	11.00



PARA RUBBER IN CEYLON.

MATURE RUBBER AT 2,600 FEET.

PASSARA GROUP ESTATE, PASSARA, UVA.

Photos lent by W. Stewart Taylor.

MANURING FOR INCREASING THE YIELD OF LATEX.

If latex is mainly an excretory or useless product it may appear doubtful as to whether manuring will have a beneficial effect on the rubber-producing capacity of the tree. This is an interesting point, and is well worth considering.

The latex is obtained from cortical tissues. These areas contain, besides the milk tubes, series of cells which store up food, and others directly associated with conducting the materials elaborated in the leaves from above downwards to various parts of the plant. These tissues are removed in the course of tapping operations, and their renewal entirely depends upon the activity of the cambium. The cambium produces new wood internally and cortical tissues externally; generally the cambium produces these two series of tissue in a definite order, and a large production of woody material is accompanied by a proportionate amount of cortical tissues. As the wood is marked off into annual zones it is therefore possible to compare the rate of growth of trees in different countries by examination of transverse sections of the trees, and indirectly to form some idea of the development of the narrow band of cortical tissues containing the laticifers.

The latex tubes form part of the cortical tissues, and an increased leaf activity appreciably affects the elements in this region. The more abundant the foliage, the more rapidly will the food material be built up and the more vigorous will the cambium become. From these and other considerations it may be concluded that if manuring is carried out, so that the growth of the leaves and woody material is appreciably increased, the cortical tissue will be proportionately increased in quantity, and there will be a larger number of cells available for transformation into laticiferous tubes. Any manure which affects the growth of the leaves or the wood must have a corresponding effect on the cortical tissues. The main object in manuring Para rubber should be to increase the number of cortical cells as rapidly as possible; this increase is dependent upon the activity of the cambium, though the subsequent condition of the newly-formed elements is closely associated with the abundance and activity of the leaves. It may appear absurd to advocate manuring with a view to increasing what is commonly regarded as mainly a waste product, but it cannot be gainsaid that abundance of cortical tissue provides more cells for perforation and disintegration, stages involved in the formation of the latex tubes of Para rubber.

The analyses of various parts of the Para rubber plant, given elsewhere, should be carefully considered when mixtures of artificial rubber manures are being compounded.

FOREST VEGETATION AND SOIL IMPROVEMENTS.

It must be remembered that Para rubber trees form a forest vegetation, and that they will grow well in relatively inferior soils providing there is a fair balance of plant food and that the climatic conditions are favourable. The soil under forest vegetation improves in mechanical and chemical composition with age, owing to the protection which the trees afford to the soil, to the action of the roots, and the accumulation of leaf-mould. The annual fall of leaf from Para rubber trees ultimately effects an improvement in the soil in which the trees are being grown. This is borne out by the analyses of the soils at Henaratgoda, the results proving that the organic matter, potash, and nitrogen are greater in the soil which has been under rubber for 29 years than that maintained under pasture; the lime and magnesia have decreased under the old rubber, while the phosphoric acid is the same under both conditions.

FOOD IN PARA RUBBER LEAVES.

The manurial value of the leaves from Para rubber trees cannot be doubted when it is remembered that the material, dried at 100° C., contains 1.72 per cent. of potash, 3.44 per cent. of nitrogen, 0.6 per cent. of phosphoric acid, and 0.51 per cent. of lime. If this material is regularly forked in either alone or with lime or artificial manures, excellent results will be obtained. The artificial manure required will largely depend upon the physical and chemical properties of the soil, but the figures showing the composition of various parts of the Para rubber plant will indicate, in a general way, the ingredients required. Potash and nitrogen are very abundant in the fresh and fallen leaves and lime is abundant in the woody structures.

MANURING OLD AND YOUNG TREES.

The method to be adopted in manuring this product is determined by the age of the trees and the kind of manure used.

Where very soluble manures such as sodium and potassium nitrate, ammonium sulphate, potassium chloride or sulphate, and similar compounds are used, they should be mixed with dry earth and broadcasted over the area where the young *rootlets are actively growing*. If such manures are applied to soil areas not possessing rootlets, the greater part will probably be carried away during the first few rainy days. After the manures have been applied the land should be forked to a depth of four to six inches, but care should be taken not to destroy many of the rootlets. Decaying rootlets may encourage ants and fungi which often prove troublesome on Eastern estates.

Where cattle manure, green manure, leaf-mould, or bulky artificial manure are used on rubber estates a slightly different method can



Photo by H. F. Macmillan.

MANURING YOUNG PARA RUBBER TREES.

(A) TRENCH FILLED WITH LEAVES OF CROTALARIA, DADAP AND GROUNDNUTS.

be adopted. The object in such manuring is not only to supply at a very short notice ingredients required for the rapid growth of parts of the plant, but to lead to the development of a quicker-growing, larger, and stronger root system. This result can be obtained if the organic manure is mixed with the soil around the trees at a definite distance according to the age of the tree. The rootlets of the Para rubber tree grow at a fairly rapid rate in good free soil, and can be easily observed; the manure should be applied at a distance just within reach of the last-formed rootlets. Around each newly-planted tree a shallow trench can be dug, about 12 inches wide and gradually increasing in depth from the tree outwards to a maximum depth of six to ten inches. The manure can then be mixed with part of the soil, returned to the trench, and subsequently covered with the balance of soil available. The distance of the trench from the tree might be approximately 2 feet or more for two-year-old trees, 3 feet or more for three-year-old trees, an allowance of about one to two feet per year being made in each subsequent year until the trees are 6 to 8 years old, when the lateral roots will almost certainly have met. The accompanying illustration shows the system applied to young plants. In this instance the leaves of *crotalaria*, *dadaps*, and *groundnuts* were buried in the trenches after mixing with lime and soil. The Para rubber plants were only six months old and the trenches 6 to 9 inches from the stems. By such a system of manuring the rubber plants will be able to obtain a supply of food at a very early stage, and the development of the rootlets from within outwards be considerably accelerated. Once the rootlets of adjacent trees have met, the manure should be either buried in shallow trenches between the trees or broadcasted and the ground forked to a depth of 4 to 6 inches or left undisturbed.

RESULTS OF MANURING EXPERIMENTS.

As previously pointed* out I have been placed in possession of the results of several manurial experiments, in which (a) green manure and lime, (b) cattle manure and lime, (c) cattle manure, lime, and artificial manures, and (d) artificial manures only, have been used on Eastern rubber estates. The results clearly show that manuring may bring the trees to a tappable size, six to twelve months before the usual time, a point which must appeal to all interested in developmental companies. The requisite quantities of the various essential ingredients vary with the age of the trees and climatic and soil conditions, and only a continuation of the experiments on a large scale can give us accurate information on this point. It appears to have been proved, however, that potash and nitrogen produce the most immediate effect, and will both be required. Nitrogen, if applied in excess or in very soluble forms, appears to be followed by a conspicuous development of foliage

* India-Rubber Journal, July 29, 1907.

not always desirable, and some care must be exercised in fixing the quantity and nature of artificial nitrogenous manures. Potash, as might have been anticipated from a consideration of analyses of parts of the plant, is needed in large quantities, and its application has so far been attended with profitable results.

CONSTITUENTS IN WOODY STEMS AND TWIGS.

In order to furnish some idea of the constituents of various parts of the rubber tree the following synopsis is given of the constituents of the fresh material, as determined by Mr. A. Bruce* :—

ANALYSIS OF PARTS OF A PARA RUBBER TREE DRIED AT 100°C.

	Fresh Leaves	Decayed fallen Leaves	Fallen Stalks	Wood	Twigs.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Water	.. 70	.. 60	.. 60	.. 60	.. 50
Ash	.. 4.69	.. 4.08	.. 3.18	.. 3.12	.. 2.62
Lime	.. 0.51	.. 1.40	.. 0.80	.. 0.80	.. 0.83
Magnesia	.. 0.56	.. 0.89	.. 0.30	.. 0.15	.. 0.17
Potash	.. 1.72	.. 0.54	.. 0.64	.. 0.30	.. 0.28
Phosphoric acid	0.66	.. 0.30	.. 0.15	.. 0.18	.. 0.09
Nitrogen	.. 3.44	.. 1.92	.. 0.84	.. 0.59	.. 0.62

COMPOSITION OF ARTIFICIAL MANURES.

The following table shows the constituents of common artificial manures obtainable from local merchants, and the compositions here quoted are those guaranteed by various firms in Colombo :—

Manure.	Potash. Per cent.	Phosphoric Acid. Per cent.	Nitrogen. Per cent.
Blood meal	.. —	.. —	.. 10 to 14
Groundnut cake	.. 1 to 2	.. 1 to 2	.. 7½ to 9
Castor cake	.. 1 to 2	.. 1 to 2	.. 6 to 7
Rape cake	.. 1 to 2	.. 2 to 3	.. 5 to 6
Nitrate of soda	.. —	.. —	.. 15 to 16
Sulphate of ammonia	.. —	.. —	.. 20½ to 21½
Chloride of potash	.. 57 to 59	.. —	.. —
Sulphate of potash	.. 49 to 52	.. —	.. —
Precipitated phosphate of lime	.. —	.. 35 to 40	.. —
Concentrated super- phosphate	.. —	.. 44 to 46	.. —
Basic slag	.. —	.. 19¾ to 21	.. —
Fish	.. —	.. 4 to 6	.. 5½ to 6½
Bone dust	.. —	.. 23 to 24	.. 3½ to 4
Nitrate of potash	.. 37 to 40	.. —	.. 11 to 13
Kainit	.. 13 to 15	.. —	.. —

* Circular, No. 6, *l.c.*



Lent by Maclaren & Sons.

MANURING YOUNG RUBBER TREES.

PARA RUBBER, ONE YEAR OLD, AND GREEN MANURING.
THIS ILLUSTRATION INDICATES HOW THE LEAVES OF DADAP
MAY SOMETIMES BE USED.

GREEN MANURING FOR PARA RUBBER TREES.

It is a fortunate coincidence that the climatic conditions favourable to the cultivation of Para rubber in the young stage are identical with those required for the plants of value as green manure. When estates are planted with rubber alone one must either elect to allow the soil to be exposed to the sun and rain and to be thereby impoverished, or decide to protect it by a green crop and increase the organic matter and mineral constituents for the future benefit of the growing rubber.

It is hardly necessary to point out the advantages of green manuring, seeing that the system is adopted in European as well as tropical countries. One great advantage attending the use of the plants mentioned below lies in the fact that they are able, in virtue of the bacteria associated with the nodules on the root, to absorb nitrogen direct from the air, a capacity not possessed by most of the plants under cultivation.

The points to be considered are during what stage in the life of a rubber plantation green manures can be cultivated, and which plants are best suited for the purpose. It is unnecessary to explain that after a good rubber estate is six to eight years old green manuring must practically cease. But during the first few years it is possible to keep a green cover over those parts of the land not affected by the rubber plants.

HERBACEOUS PLANTS.

Herbaceous plants can be best grown from the first to the fourth year on account of the abundance of light they are able to obtain, and the relative freedom of the soil particles from the roots of other plants. The plants which can be used are *Crotalaria striata*, D.C., *C. laburnifolia*, L., *C. incana*, L., *Cajanus indicus*, Spreng, and species of *Indigofera* and *Cassia*. These plants are shrubby in habit, grow to a height of one to five feet, and will stand pruning at intervals of four to six months. Trailing or creeping plants such as the groundnut and species of *Vigna* can be successfully grown and also the sensitive plant. All these plants give a good cover to the soil and help to keep the weeds in check; they produce large quantities of organic matter rich in plant food. Space forbids a full account of this subject, but the following facts are of interest as showing the weight of green material obtainable and the composition of several species:—

Name of Plant.	Weight of Organic Matter per Acre.	Time between Sowing and Uprooting.
<i>Crotalaria striata</i> ..	20,244 lb.	.. Ten months
<i>Vigna</i> ..	12,092 „	.. Four months
Pondicherry groundnut..	4,692 „	.. Five months

COMPOSITION OF VARIOUS GREEN PLANTS, IN THE FRESH STATE.

Name of Plant.	Nitrogen. Per Cent.	Potash. Per Cent.	Phosphoric Acid. Per Cent.	Lime Per Cent.
Crotalaria striata	.. 0·7 to 1·0..	0·47	.. 0·154	.. 0·210
Vigna	.. 0·6	.. 0·738	.. 0·177	.. 0·727
Pondicherry groundnut	0·914	.. 0·493	.. 0·155	.. 0·242

It is interesting to work out what the equivalent of 15,000 lb. of green manure of *Crotalaria striata* is from a purely *theoretical* standpoint.

According to the above analyses it is approximately equal to a manure of the following composition :—

	lb.
Castor cake ..	500
Blood meal ..	500
Nitrate of soda ..	140
Basic slag ..	115
Potassium sulphate ..	140

If the whole of the material is to be used, it should be buried with lime or basic slag around the trees or forked in as previously explained. During its decomposition it leads to the liberation of large quantities of plant food, which would otherwise remain in a latent stage for many years.

For the successful cultivation of the herbaceous green manures about 10 to 20 lb. of seed, per acre, should be broadcasted on clean land in wet weather and the land lightly forked. In Fiji as much as 50 lb. of *Vigna* seed is used, per acre, in connection with other products.

An illustration is here given to show the characters of *C. striata*, when only six months old. The young rubber, a year old, is just showing above the *Crotalaria*; the latter covers nearly the whole of the ground and tends to check the growth of weeds

TREE FORMS.

The best tree forms to use for green manure are Dadaps (*Erythrina* species) and *Albizzia moluccana*. Dadaps can be propagated from cuttings; in some districts they will give a very large amount of organic matter within a few months from planting the cuttings; plants can also be used, though the organic matter obtainable from them within a couple of years is less than that from cuttings in a few months. If cuttings are used, they can be planted between every two rubber plants. The best results are obtained if the cuttings are about two inches in diameter and four feet long with one foot below ground; they should be planted in very wet weather. Dadaps can be used on hillsides where the cultivation of herbaceous green manures is practically impossible. They should be lopped or



Photo by H. F. Macmillan.

RUBBER AND GREEN MANURING.

YOUNG PARA RUBBER AND CROTALARIA STRIATA

hand-pruned as frequently as possible and the material buried in the same manner as for other species. The following table shows the weight of fresh leaves obtainable from one acre of Dadap cuttings planted 4 by 8 feet apart in July, 1904

			lb.
November, 1904	..	..	791
December	..	..	967½
March 1905	..	..	1,935
April	..	..	1,444½
May	..	..	2,255
June	..	..	2,240
July	..	..	2,180
August	..	..	3,058
September	..	..	1,569¾
November	—	..	2,104½
December	—	..	1,653½
Total			20,193½

These experiments show that Dadap cuttings may produce over 11,000 lb. of fresh green leaves within one year from planting, and the leaves may be hand-pruned nearly every month in the year. The fresh leaves contain 0·3 to 0·8 of nitrogen, 0·148 of potash, 0·08 of phosphoric acid and 0·197 of lime.

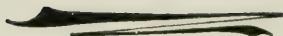
ALBIZZIA.

Albizzia moluccana is one of the quickest-growing trees known, but it is not easily propagated from cuttings. The woody tissues preponderate, and the weight of leaf obtainable within one or two years is less than with Dadaps. The leaves are a valuable plant food, and if the trees are regularly lopped will give a fair amount of material fit to be buried. A one-acre plot, planted in July, 1904, 20 feet apart, gave up to January, 1906, 3,246 lb. of green material and woody twigs, so that if planted as close as the Dadaps (8 by 4) they should yield about 13,000 lb. per acre per year. On some rubber estates the young *Albizzia* plants have been so pruned as to be easily overtopped by two-year-old Para rubber trees, the branches and foliage of the *Albizzia* trees covering the greater part of the soil. The fresh leaves contain 0·395 per cent. of nitrogen, 0·406 per cent. of potash, 0·178 per cent. of phosphoric acid, and 0·441 per cent. of lime.

If it is found necessary to plant belts of trees enclosing various sections of a Para rubber estate for the purpose of checking the spread of disease, the possibility of using mixed lines of Dadap and *Albizzia* trees should be worth considering; the former can be easily pruned and made to produce a close low-lying bushy fence, and the latter allowed to grow and form a belt of foliage and branches above the tops of the Dadap plants.

GREEN MANURING IN MALAYA.

Ridley maintains that in the Straits and F.M.S., manuring the trees by the trenching system or the interplanting of Para rubber trees with Dadaps is not to be recommended as it involves an interference or destruction of the roots and cutting out at a later date. He is of the opinion that green manuring in the Straits and F.M.S., should be done only with herbaceous plants, and these should be merely cut and thrown on the ground and not dug in.





SCULFER'S TAPPING KNIFE.



MILLER'S TAPPING KNIFE



SRINIVASAGAM'S TAPPING KNIFE.

CHAPTER VI.

TAPPING OPERATIONS AND IMPLEMENTS.

Importance of tapping operations—The thickness of the bark tissue , and shedding of dried latex tubes—Effect of bad tapping illustrated—Tapping knives—Requisites of a good tapping knife—Recommendations of judges at the Ceylon Rubber Exhibition—Clean cuts and scraping—Protection of the cambium—Paring from right to left and left to right—Minimum excision of cortex and bark—Paring and pricking—Patent tapping knives—Native implement—Carpenter's chisel—Surgical scrapers and planes—Beta knife—Golledge's knife, construction and illustration—Holloway's knives—Mackenzie's knife—Collet's knife—Brown & Co.'s knives, construction and illustrations—Eastern Produce and Estates Co.'s knife—Bowman's and Northway's three knives, construction, method of use, and illustrations—Dixon's knife, construction, improvements, and illustration—Macadam's Comb pricker—Macadam-Miller paring knife—Miller's knife—The Farrier's knife—Pask-Holloway knife—The "Secure" knife—Kerkchove's knife—Walker's Combination knife—"Scorpion" paring knife—Srinivasagam's knife—Tisdall's Knife—Sculfer's Tapping knife—Bowman-Northway knife.

THE question of how to tap Para rubber trees is one which deserves special consideration and is not outweighed in importance by even the process of curing or methods of planting this species. On the methods of tapping depend not *only the quality and quantity of the latex and rubber, but the life and future condition of the trees*

We are concerned with the laticiferous tubes in the outer part of the stems when the trees are ready for tapping.

The thickness of this tissue may vary from $\frac{1}{8}$ to about $\frac{1}{2}$ inch or more, according to the age of the tree.

The average thickness of the undisturbed bark of twenty-year-old trees in Ceylon is about $\frac{3}{8}$ inch (9.5 mm.), though trees at Singapore, only 11 years old, possess bark of this thickness. The outer part to a depth of $\frac{1}{8}$ inch (3 mm.) does not contain many tubes, but the inner part has a large number, and from the inner $\frac{1}{16}$ to $\frac{3}{32}$ inch the milk mainly flows. The tubes in the outer part dry up and are regularly shed with the outer bark tissues.

When the original cortex has been removed new tissue is produced, mainly from above downwards and within outwards, and in this the latex tubes arise *de novo* as in the original material. It is important to remember that the extension of these tubes in the cortex of *Hevea* is a gradual one, that in many instances the parts of the laticiferous system are not extensive, and in tapping operations only a fraction of the whole milk-containing tubes may be drawn upon.

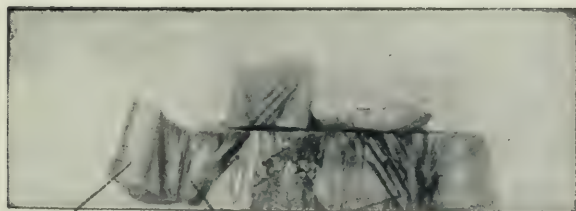
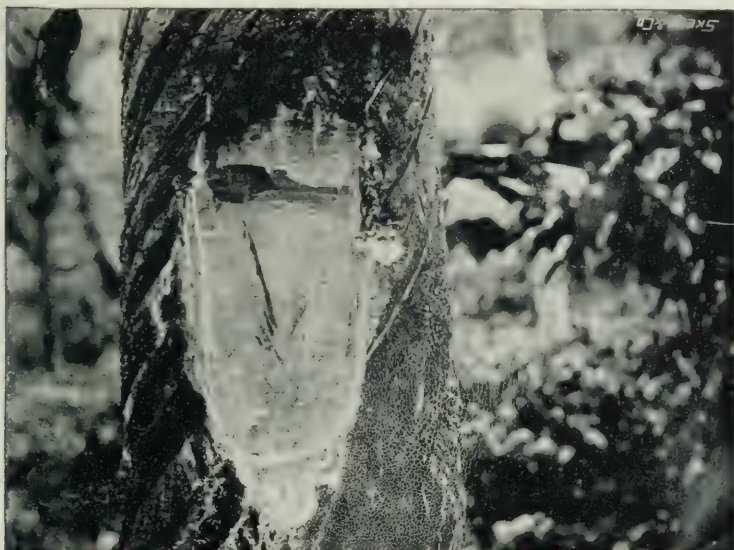
Recent experiments have shown how improvement can be made on the old method of tapping every alternate year and obtaining $1\frac{1}{2}$ lb. of rubber per tree, per year, from eleven-year-old trees. It has been stated that the yields possible in the near future may, if present prices are maintained, be such as to allow one to consider the contingency of re-planting every twelfth year. The yield obtained in some parts of Ceylon shows that by somewhat drastic methods it is possible to procure from particular trees in one year's tapping as much as the most sanguine only a few years ago anticipated in ten years' tapping, though it must be borne in mind that the effect on the trees cannot, with our present knowledge, be accurately forecasted and may or may not prove to be detrimental.

EFFECT OF BAD TAPPING.

It is more than likely that the tapping implements and methods of the future will be such as to ensure that the minimum, if any, damage is done to the cambium. With all due respect to the inventors who have placed their knives before the public, it may be stated that the faultless or ideal paring implement has not yet been produced, though there seems every likelihood that it will soon be on the market. There are still several implements sold and used which should be classed as dangerous. In order to impress all planters with the ultimate effect of bad tapping, a couple of photographs are here reproduced.

In the accompanying illustration the upper figure shows a part of a large tree with the bark and part of the wood removed. The large approximately V-shaped hollow in the exposed section is due to the decay of the wood, which occurred internally to a depth of several inches, and was caused originally by making a large V wound that scraped *below the cambium* into the timber all along the incision. The lower figure on the same Plate shows a section of the wood with part of the bark and outer tissues removed. The wood was, with the original tapping, considerably damaged, and several years after the injury was made the parts above it were found to be very hard and to give very little latex: the wood was permanently damaged. In this particular case the outward appearance was not striking in any way, and only the poor yield of latex led to an inquiry which revealed the extent of the permanent injury that had been made. The black V-shaped lines in the exposed wood show the direction and extent of the old Vicuts; these penetrated to the

EFFECT OF BAD TAPPING ON THE WOOD.
SHOWING DECAY OF INTERNAL WOOD WHERE INJURED BY TAPPING.



A

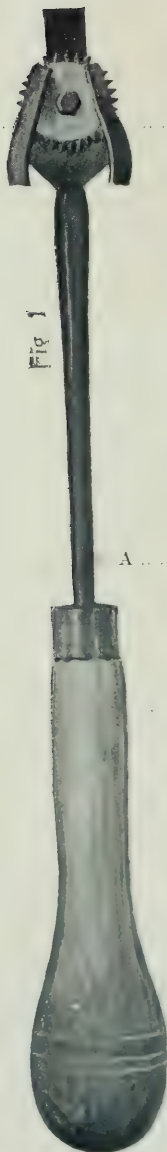
B

Photos by M. Kelway Bamber.

(A) OUTER WOOD REMOVED; (B) DARK V LINES INDICATING THE DECOMPOSITION
OF THE WOOD.

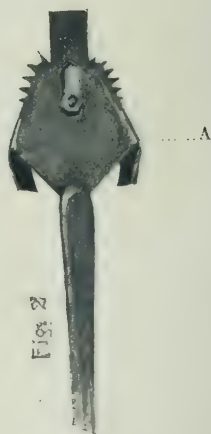


THE "SECURE" TAPPING KNIFE.



WALKER'S PARA COMBINATION KNIFE.

A. These Blades are detachable.



cambium. In all such cases the decomposition of a vital part of the tree has been set up, and the vigour and longevity of the tree appreciably affected. I have seen several other malformations produced by damaging the wood while tapping; often the areas become very "warted" and present a series of very large balls of hard woody tissue incapable of being tapped, and which seem to rest in sockets of the timber; in other cases large scars exist where the chisel has cut below the cambium. The injury in all cases is permanent and can be detected many years after it has been made. Such knobs and scars are not due to "canker," and the establishment of a smooth surface on such trees without cutting into the wood is practically an impossibility.

The tapping of irregular surfaces requires special consideration; but it may be stated that in no case should the woody protuberances be excised; the incisions should, if possible, be made above or below all woody warts, and the latter allowed to work themselves out in their own way and time. In such cases the zig-zag method of tapping (see next chapter) can often be adopted with advantage.

TAPPING KNIVES

The various methods of tapping now in vogue are often associated with the use of a particular knife or series of knives, and it is therefore necessary to first consider the knives commonly used and the general requirements of such implements.

REQUISITES OF A GOOD TAPPING KNIFE.

There are several points which should be borne in mind by those who desire to effect improvements in tapping knives or to invent new ones.

In the official report of the judges at the Ceylon Rubber Exhibition, the following points were considered in connection with the tapping knives exhibited:—

1. *Thinness of paring*:—Under this head the judges decided that the uniformity of the section; adjustability; cleanness of cut or absence of drag; and efficiency of the guard or control of the section were points of practical importance.

2. *Convenience and facility in operation*:—In this group the points considered related to the muscular effort required; visibility of cut during tapping operations; capability of cutting in all directions; suitability for unskilled labour; absence of clogging; and prevention or impossibility of incorrect use by cooly.

3. *Simplicity and durability*:—These items necessitated a study of the price; length of life; retention of sharpness; facility for

sharpening; and lack of complication in relation to each knife. The primary considerations are as follows:—

The first requisite is that the cutting surfaces shall be such as to enable the operator to either make an even clean cut or to excise the cortical tissues without dragging the cells or clogging the knife. Several friends have shown me instruments which are best described as surgical scrapers, planes, and closed knives; in each case the idea was to *scrape* away a thin film of the cortical tissue, but in every instance the operation dragged the cortical cells considerably, clogged the latex tubes, and left an uneven surface along which watery latex would not flow. A clean cut is essential, and for this reason it is doubtful whether the principle of scraping will ever be generally adopted.

A second point of very great importance is that the knife should, if possible, be provided with some structure which will prevent the cooly from cutting too deep when making the initial excision, and also protect the cambium during subsequent paring operations. In several cases separate knives are used for making the original incision and subsequent paring operations; those used in the latter processes are frequently made so that they can be adjusted beforehand, or they are protected by a fixed or detachable blade. A glance at the various photographs and diagrams will show the appliances referred to. The effect of bad tapping is shown elsewhere. It is a great advantage if the cutting parts can be adjusted with ease and replaced without great expense.

A third consideration, which should not be lost sight of, is that the knife should be one which can be used in cutting from left to right and right to left from above downwards. Several illustrations show knives which can be so used, and also from below upwards if desired. This is a necessary qualification in all tapping methods except the right-hand half-herring-bone and spiral systems.

A fourth point, which has obviously received attention in the knives recently put on the market, is that the instrument used for re-opening or paring the lower surface of the wound should be so constructed that only the minimum quantity of material is cut away at each operation. The longevity of the tapping area depends upon this operation, and at the present time there are knives capable of demolishing 12 inches of bark in three months, and others which will not use up the same quantity of tissue in two or three years. The very narrow cutting margins of several knives are specially devised for paring away very thin shavings of the bark.

The introduction of pricking instruments for cutting the laticiferous tubes in the wound area, though duplicating the tools, is very useful; generally the duplication of the tools required to make the

TISDALL'S TAPPING KNIFE.





CAMERON BROS.' "SCORPION" TAPPING KNIFE

first and subsequent incisions is undesirable, and in several instruments the power of adjustment is such as to allow all the operations to be carried out by means of one knife only.

PARING AND PRICKING.

The amount of cortical or bark tissue removed by one paring operation is sometimes surprisingly large. The average cooly will excise the lower surface until a large number of white globules of latex have appeared, when by the use of other implements the latex tubes might have been tapped without excising any cortical cells at all. It has been asserted that since the most careful method may only allow one to tap the whole of the surface from the base up to six feet in two to three years, the care advocated is not necessary when large acreages have to be tapped. But the necessity for tapping every tree on a large plantation is no excuse for excising the cortical tissues in a wasteful manner. The best results will accompany those methods involving the removal of the minimum amount of cortical substance during tapping operations.

It has been urged that even if one removes large quantities of tissue when tapping, the rubber can still be extracted from the material thus removed. This is correct especially when large quantities of bark are cut away, but the greater part of the rubber can, by proper paring and pricking, be removed without great waste of tissues.

Furthermore, it should be distinctly borne in mind that the removal of the cortical cells means the destruction of living tissues wherein the latex tubes arise. The actual quantity of rubber in the cortex at any particular time is very small compared with that which can be obtained by pricking the latex tubes, allowing them to become refilled, and encouraging their development.

PATENT TAPPING KNIVES.

The native collectors of rubber in the uncultivated forests of Brazil use an axe-like implement, with which a heavy blow can be inflicted and all the tissues from the bark to the cambium be cut in one stroke. At the present time Ceylon is taking a very active interest in inventing and improving tapping knives for use in obtaining latex from Para rubber trees, and the following accounts of some well-known implements will be of value.

THE CARPENTER'S CHISEL.

This was used in the early tapping days, but has been superseded by more useful tools. Parkin carried out experiments to see "whether incisions made with a stone or cold chisel gave more latex than corresponding ones made with an ordinary chisel, but did not find any appreciable difference in the amount of latex collected from the two kinds of incision on the single oblique pattern." He finally

recommended a wedge-shaped chisel with a thickness of $\frac{3}{16}$ to $\frac{1}{4}$ inch, at a distance of $\frac{1}{2}$ inch from the cutting edge; the breadth of the chisel varied from 1 to $1\frac{1}{2}$ in.

With the idea of re-opening the wound area without cutting away a large quantity of tissue several surgical scrapers and planes have been brought forward, but in every case have proved unsatisfactory. They tend to clog the freshly-opened latex tubes.

THE "BETA KNIFE."

The Beta knife, placed on the market by Messrs. T. Christy & Co., is, according to Johnson, a useful instrument; the length of the blade is regulated by means of a screw to suit the varying thicknesses of the bark of different trees and so prevent its damaging the wood of the tree.

GOLLEDGE'S KNIFE.

In the accompanying illustration it will be seen that this knife consists of a flat piece of steel provided at the end with a short sharp bevelled V and a cutting groove along the sides. The knife can be used for making cuts from above downwards, below upwards, and from left to right or right to left. It can be used to make the original incision and during subsequent paring operations. The illustration showing the herring-bone system of tapping, at Gikiyanakanda, indicates the good work done by means of this knife.

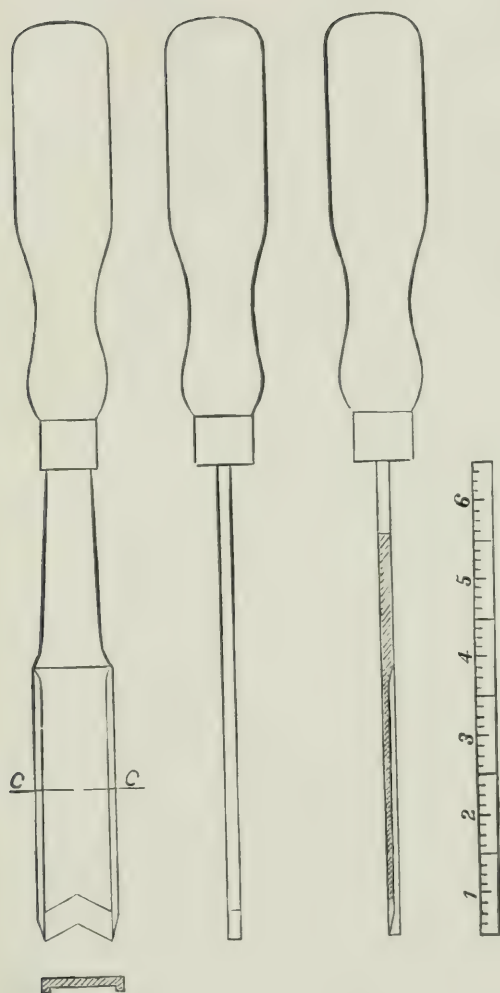
HOLLOWAY'S KNIVES.

The Holloway tapping tool is an improved V knife provided with movable blades; the V head is fastened to the handle by two small screws and nuts, and the blade when worn down is easily replaced.

Holloway has brought out another knife which is essentially provided with a two-flanged and a basal cutting surface. The blade is made of metal and is curved like a hook at the top; the cutting area is provided with a flange at either side at right angles to the base, and all parts can be easily sharpened. The basal cutting surface or either of the angles can be used in making the original incision, and the two angles may be used for paring either from right to left or left to right. The parts are changeable and all operations can be done with one implement.

MACKENZIE'S KNIFE.

This consists of a tempered steel head of box section having cutting edges on three sides. The cutting surfaces are in one piece and movable; by an ingenious screw arrangement the depth of the cutting edges can be adjusted according to requirements by two side guards. The knife can be used for tapping from left to right or right



SECTION CC

GOLLEDGE'S KNIFE.



THE "SAFETY" TAPPING KNIFE.



THE PARA CHISEL.

Lent by Brown & Co.

to left. When the incision is so broad that the guard on the upper side of the knife does not rest against the bark on the top side of the cut, the upper guard can be lowered so as to come in contact with the excised area, along which it rubs during paring operations.

COLLET'S KNIFE.

M. Collet recently exhibited a new tapping knife which I am informed has been patented in Belgium. It is made entirely of metal: running down the handle, and coming out at the base, is a bluntly-pointed piece which is inserted in the bark of the tree to be tapped, and by this means the depth of the bark is measured

The blade of the knife is like a sharp, curved gouge, and has on it a brass support, which is set at an angle with the blade and—before cutting—is adjusted at a definite angle, so that when the knife is in use and the brass support resting against the bark, the cut can only go as deep as it is set for, that is the depth of the bark measured at first; by this means the laticiferous cells are reached, but the cambium is not cut.

THE “PARA” RUBBER TAPPING KNIFE AND CHISEL.

The two instruments indicated are obtainable, from Messrs. Brown & Co., Colombo. The “tapping knife” is designed for making the first incisions in rubber trees, when the paring process is intended to be carried out in the subsequent tapping rounds. It is constructed to make incisions on the left and right of the perpendicular, and after these cuttings to leave flat surfaces on the lower sides of the incisions; it provides ample head room for the “*Para Chisel*” to work in during the early rounds of paring. The “*Para Chisel*” is a tool for re-opening the original incision in such a manner as to renew the flow of latex with the minimum loss of bark tissue. It is first adjusted to cut to the required depth, then placed in the incision and pressed gently forward in a direction parallel to that of the incision. The cutting blade can be easily renewed. The accompanying illustration shows the construction of the important parts.

AN IMPLEMENT FOR TAPPING RUBBER TREES.

The Eastern Produce and Estates Company are responsible for a knife, already largely used on many estates in Ceylon. The patentee claims that it is a simple knife and one which can be economically used over large acreages of rubber. It consists of a wooden handle of suitable size and shape, furnished at one end with a stabbing or piercing point for the purpose of clearing the old cuts of scrap rubber; it is occasionally used on estates for piercing the stem or newly-formed cortical tissue to see if the latex is abundant. The cutting device is mounted at the other end of the handle and consists of a haft or stem with a hollow wedge or triangular-shaped cutting portion at the apex. This knife was one of the first to be

placed on the market, and a detailed account of it is given in the India-Rubber Journal of February, 1904.

BOWMAN'S AND NORTHWAY'S KNIVES.

These knives have been continually used in the experiments at Peradeniya and Henaratgoda, and in response to suggestions the originals have been slightly modified in order to be of use in any of the numerous systems of tapping, and to still further economize in the removal of the cortical tissues. There are three knives in all: No. 1 for making the original groove, No. 2 for re-opening the lower surface of the wound, and No. 3 for pricking the latex tubes in the area of the wound response without removal of any cortical tissue. These knives are shown in the accompanying illustrations.

Knife No. 1 is provided with a two-edged guide, which on pressing against the bark cuts the tissue and defines the area to be cut away by the knife edge behind it: by this means the original groove shows clean cut surfaces above and below. It is used much like a plane, the head being suitably adjusted to shave the bark gradually; as soon as the proper depth is reached the bark is of a white colour and becomes lighter and lighter the nearer one gets to the *cambium*, so that by practice it is possible to tell almost correctly when the right depth has been cut.

Young trees are more difficult to cut to the correct depth than old ones, as the latex-bearing tissues below the bark and next to the *cambium* are very thin indeed; it is therefore advisable to mark lightly with No. 1 and reach the correct depth gradually with a few tappings with No. 2 in the manner described below for cutting deeper.

Knife No. 2 in its improved form is very ingenious. The cutting part consists of three surfaces, a narrow basal one along which a spring blade is inserted, and two side surfaces at right angles to the basal one. When the flexible spring blade is inserted there are two small cutting edges available, one to use when cutting from right to left and one for use from left to right. Several of the No. 2 knives are only provided with one angular cutting surface. By this means only a very thin layer of cortical or bark tissue is removed during each paring operation, the removed substance being so small that it takes quite 30 parings to remove one inch of tissue. This is a most important point, as the bark is made to last considerably over one year instead of only 3 to 6 months. This knife is used only for paring off the lower edge of the grooves originally made, and when in use should be held so as not to make the cuts deeper than the previous ones; this is effected by holding the knife at the proper angle. Leaning the knife over to the right makes the cut deeper, while leaning over to the left makes it less deep. The knife is constructed to prevent the coolly cutting deep enough to touch the *cambium*.



Photo by D. L. Goonewardane.

BOWMAN'S AND NORTHWAY'S KNIVES.



DIXON'S TAPPING KNIFE.

The basal cutting surface of this knife has now been made much narrower, the change effecting a greater economy as less material is likely to be removed during each operation.

No. 3 consists of a spur-like arrangement, provided with a number of sharp cutting teeth. It is used to cut the latex tubes near the cambium or to tap the milk vessels which have become unduly distended with latex.

The latest patterns are provided with one or two pieces of metal, the solid margins of which prevent the teeth from penetrating too deeply; these can be changed in order to allow the teeth to penetrate the cortex to the necessary depth—a wise provision when tapping trees of widely different ages. It can be used alternately with No. 2 knife, though in the Peradeniya experiments the spur knife was used at least twice as often as knife No. 2. It was by the use of these knives that a yield of 12 lb. of rubber was obtained in 6 months from an eleven-year-old tree in the south of Ceylon, and 4 lb. in two months from each of four trees at Peradeniya. The knives have elicited the admiration of many rubber planters who have adopted the pricking and paring method. The value of a pricking instrument does not appear to be fully appreciated by many, but when it is pointed out that by means of such an implement the excised area in three months' work, tapping twice per week, is less than one inch, its usefulness cannot be doubted.

DIXON'S KNIFE.

This consists of a grooved open knife blade, capable of being adjusted to cut the bark to any depth or at any angle. The cutting part can be easily removed from the handle of the knife and is therefore capable of being replaced when worn out. The base is provided with a pricker for determining bark thicknesses, removing scrap rubber from the cuts and making holes for attaching tins, &c. It can be used for making the original groove or for paring the lower surfaces in any direction, the excision being made by drawing the knife towards the operator.

In a later pattern the cutting blade is provided with sharp margins, two blades, detachable and adjustable, to be used according to particular requirements. By favour of Mr. Dixon the accompanying illustration is here reproduced.

MACADAM'S COMB PRICKER.

Another type of pricking instrument has been introduced by Mr. Macadam of Culloeden estate, Kalutara; this is worthy of a detailed description as it is constructed on a sound principle and is different from any other pricking instrument known. In order to distinguish it from others I propose to name it a "Comb" pricker. It consists essentially of a flat steel blade or comb provided with a dozen sharp teeth on one side; the teeth are 5 mm. wide and 9 mm.

long and the blade is $11\frac{1}{2}$ cm. in length, so that a tapping line one foot in length ($30\frac{1}{2}$ cm.) could be pricked in three operations. The blade slides along two side grooves and is provided with two projecting pieces of metal for handling during adjustment. The blade can be pushed outwards or drawn inwards, thus allowing only a definite length of each tooth for the pricking operation. The ease with which the length of all the teeth can be adjusted is a great advantage, as a cooly going from tree to tree can, though he only possesses one piece of metal, accurately change the length of the teeth according to the thickness of the bark on the trees being tapped.

A further advantage in the "Comb" pricker is that the latex tubes are incised by merely pressing the line of teeth against the cortex; dragging of the bark cells is therefore almost impossible. In other prickers the tapper naturally draws or pushes the instrument in a particular direction, and the unavoidable dragging may result in a clogging of individual milk tubes. The teeth of the "Comb" are very easily sharpened, and the simple and effective apparatus is mounted on an arched handle whereby a good grip is obtainable and the required pressure applied during tapping operations.

THE MACADAM-MILLER PARING KNIFE.

This paring knife consists of two detachable paring surfaces connected by a screw roller; the cutting parts are on opposite sides and may be moved outwards or inwards by turning the screw, and can therefore be adjusted according to the depth of the bark to be excised. The essential parts are lodged in a substantial steel head firmly attached below to a wooden handle. The knife is constructed so that the operator may cut from right to left or left to right, from above downwards or below upwards. The essential parts are rather difficult to get at and may prove troublesome to a cooly who is not accustomed to adjusting the paring edges.

MILLER'S KNIFE.

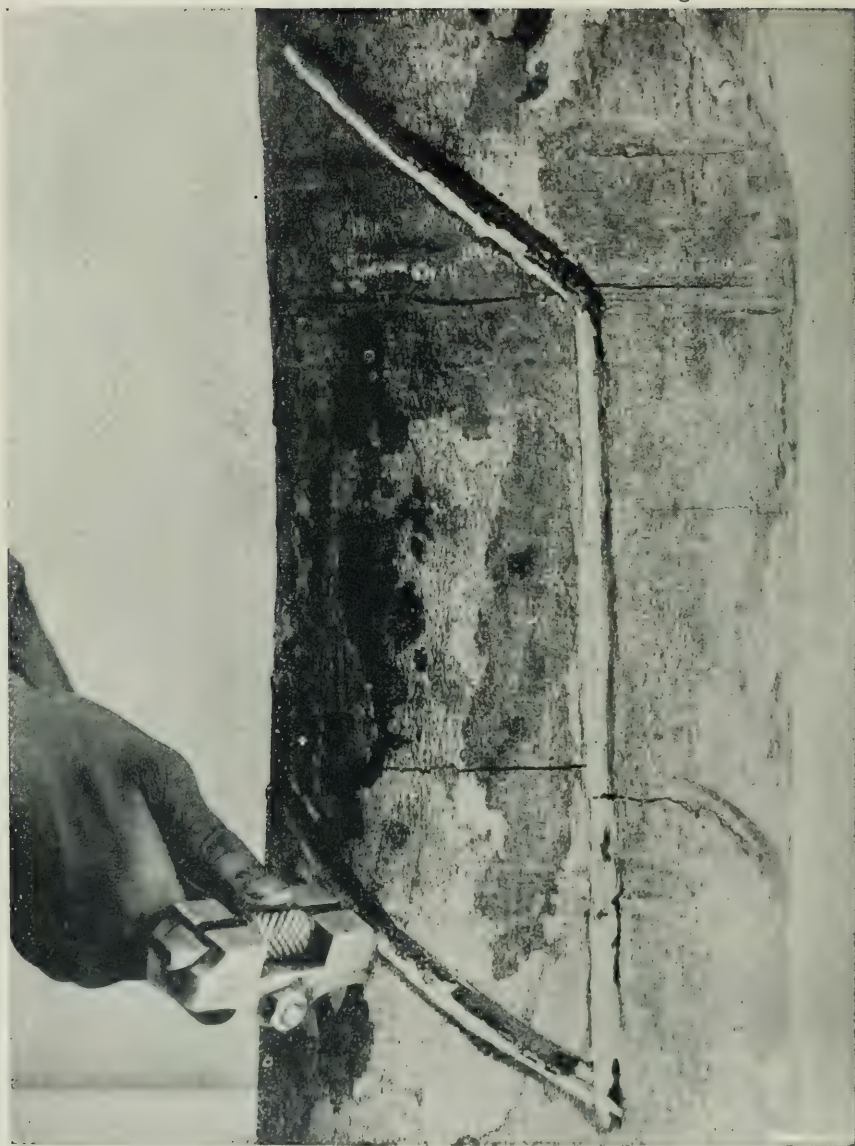
This knife was, at the Ceylon Rubber Exhibition, classed as equal with the Bowman-Northway knives. It is very simple and consists of a rectangular or box-shaped piece of metal, open at both ends, and provided with four cutting edges; it can be used for excising bark from right to left, left to right, below upwards, and above downwards. The base of the cutting surface is drawn out at both ends to form a fixed, sloping guard which prevents the operator from cutting too deep. It is simple, non-adjustable, and capable of paring only the thinnest strips of bark.

SCULFER'S KNIFE.

A cheap and durable knife has been brought out by Mr. H. G. Sculfer. The knife is fitted with a guide which allows only a small paring to be taken off at each cut, also stopping any danger



MACADAM'S COMB PRICKER.



MACADAM-MILLER KNIFE

of cutting the cambium. It will cut either right or left, pulling or pushing, and is easily sharpened and there is no possibility of the knife choking.

THE FARRIER'S KNIFE.

This knife is one of the simplest on the market at the present time; it consists of a long piece of metal turned on itself at the end to form a cutting curve. It is said to be largely used on some estates in Malaya and to give satisfactory results when the coolies have had fair experience. There is hardly any limit to the damage which can be done by such a knife, but to those planters who crave for simplicity and a tool which cannot be adjusted at will by the coolies, this form should appeal.

PASK-HOLLOWAY KNIFE

This knife is designed to cut thin sections of bark during tapping operations. The rectangular-shaped piece of metal at the end of the blade is almost blocked so that very narrow cutting edges remain for excising the bark. The cutting section of the metal is, to some extent, adjustable and is attached to the block by means of a bolt, and can therefore be removed and easily replaced. It is a strongly-made knife and can be used for the initial and subsequent cuts. The double cutting edge enables right and left hand cutting to be done, and the paring can be changed from medium to narrow.

THE "SECURE" KNIFE.

Messrs. Thomas Newey and Sons have brought out a tapping knife which is strongly made and serviceable. The knife will cut in either direction, pulling or pushing, and can be adjusted according to the thickness of the bark to be tapped. The blade is joined to a circular disc by means of a bolt and fitted so as to rotate in a slide to any angle required. The circular base and disc are toothed and lock securely in any position. The pin has a square shoulder to prevent turning, and the shank is riveted in the handle.

KERCKHOVE'S KNIFE.

G. Van den Kerckhove has patented a knife, which he states is specially adapted for tapping rubber trees and vines. The knife consists of a steel spike, with handle; at the end of the spike, which is slightly curved, is a plate with a screw and three moveable blades with oblique edges. These blades can be regulated according to the thickness of the bark to be cut; the blades can be used combined or singly, according to requirements.

WALKER'S COMBINATION KNIFE.

An ingenious knife has been recently brought forward by Mr. H. E. Walker, provided with paring section and rotatory pricker. The claims of the inventor are as follows:—

(1). The combination of shaving blade and pricking spur allows the operator to use either (a) blade and spur in the same operation,

or (b) blade or spur separately without removing any part; (2) by pressing the guard against the trunk it acts as a guide and causes the spur to prick the latex channels in the innermost layer of the cortex, but prevents the teeth from going too deep; (3) the spur may be easily adjusted by means of the slot in which it is fixed and made to penetrate to varying depths, or withdrawn from use, without removal of any part of the instrument; (4) the form of the spur is such that during use it will only prick the bark on which it is used; (5) the guards are made at such an angle with the blade that the excised plane will always, when properly used, be inclined towards the tree and thus prevent overflowing; (6) the knife can be used for right or left-hand tapping without any adjusting.

THE "SCORPION" PARING KNIFE.

This knife, more generally known as Cameron Brothers' "Scorpion" Paring knife, is claimed to be one which will enable a skilled tapping cooly to pare 300 lineal feet in one hour, on trees 25 feet apart carrying 2 feet of tapping line each.

The cutting parts have been designed to allow the operator to pare thick bark shavings $1/18$ th of an inch in thickness.

TISDALL'S KNIFE.

This knife, which received commendation at the Ceylon Rubber Exhibition, consists of a long piece of metal curved at the end to form a cutting blade, and with a revolving disc attachment which can be adjusted to regulate the depth of cut. This knife is illustrated elsewhere.

SRINIVASAGAM'S KNIFE.

This knife is designed to make the original incisions, to pare off thin shavings, to channel the side of the tapping cut, and to clean the trees or remove dead bark. The boat-shaped front prevents the cooly from cutting too deep, the clip protector guards the cutting edge, and the openings at the sides allow the bark shavings to escape.

BOWMAN-NORTHWAY KNIFE.

A new knife has been recently brought forward by Messrs. Bowman and Northway of Ceylon and has been fully described and illustrated in the "India-Rubber Journal" of January 13th, 1908. The cutting part is shaped like the letter T. The cross part of the cutter has its extreme points turned up at an angle and sharpened at both ends. Guide pins are provided to regulate the depth of the cut and the thickness of the shaving, and also to sustain the tool with the blade at a correct angle. The implement can be used either on the right or left hand and will cut either backwards or forwards.



Lent by Maclaren & Sons.

THE BOWMAN-NORTHWAY "SIMPLEX"
KNIFE IN USE.



Photo by C. H. Kerr.

Lent by G.H. Colledge.

PARA RUBBER IN CEYLON
KALUTARA DISTRICT.
TAPPING OPERATIONS AT GIKIYANAKANDA.

CHAPTER VII.

HOW TO TAP PARA RUBBER TREES.

Methods of tapping Para rubber trees—Methods of native collectors in Brazil and on the Gold Coast—Observations of Jumelle and Bonnechaux—Modern methods—Single oblique cuts, illustrated—V incisions, illustration showing a tree after ten weeks' tapping—Limited area—Herring-bone system—Photographs of trees in Ceylon tapped on the herring-bone system—The zig-zag method and its use—Spiral curves—F. Crosbie Roles on the spiral method, yields and estimates—Results of the spiral system in parts of Ceylon—Collecting and storing of latex—Bury's protector—Centralizing the latex from many trees.—Drip-tins, their construction and action, illustrated—Keeping the latex liquid and settling tanks—Method of marking the trees for tapping—Collecting tins.

METHODS OF TAPPING.

The best method of tapping is that which extracts the maximum amount of latex from the tree with removal of the minimum quantity of cortical tissue, and without damaging the thin layer of cambium cells. The cambium is responsible for the renewal of the cortical tissue in which the latex tubes arise by a process of perforation and decomposition at a later stage. If the cambium is damaged the repairing of the cortical tissue is long delayed, and in very many cases the areas so damaged can never be tapped to the same advantage as previously.

At Henaratgoda and on estates many examples of the effect of injuring the cambium may be seen at the present time, though the damage may have been done many years ago. The surface of a badly-tapped tree does not become even and smooth for many years, and tapping on the best system on such trees is difficult and often impossible.

METHODS OF NATIVE COLLECTORS IN BRAZIL.

The felling of the wild trees and the ringing of the bark and cortex in order to collect the milk are now rarely practised by native collectors. The latex is usually collected from the trees while standing, and in the Amazon districts an upward incision is made in the bark by means of a small axe, and a cup is then placed beneath each cut.

According to Jumelle,* M. Bonnechaux has investigated many of the Brazilian forests, and the information regarding the rubber from Hevea species which that explorer has compiled is of interest to all cultivators of Para rubber. The collection of caoutchouc is mainly from species of Hevea, but certain species of *Sapium* are credited as yielding good latex which is frequently mixed with that from the Hevea trees.

According to Bonnechaux, the Hevea trees are to be found in groups of from 120 to 180 wild trees, mainly along the courses of the rivers. When they are numerous the average distance between two Hevea trees is about 30 steps; when less abundant, about 50 steps; and where more widely scattered the collection of caoutchouc is considered to be too difficult and laborious. The trees on one group were measured by Bonnechaux and varied from 0.25 to 0.90 metre in diameter. (1 metre=about 39½ inches).

Collecting operations are, according to the above authority, commenced in July when the rainy season is drawing to a close and when the rivers are low, and are continued until February. Tapping is commenced in the morning immediately after sunrise, the men making their incisions from below to a height of about six to seven feet with axes; receptacles are fixed in the bark and the latex allowed to run into them, while the tapping of other trees is continued. In other parts of Brazil the latex is collected by puncturing the bark and conducting the latex by means of the leaf stalks of *Mauritia flexuosa*, Mart., to the apex of a V, where a receptacle is placed. The receptacles have a capacity of 10 to 20 centilitres, three or four being used for trees having a diameter of 50 cm., (19½ inches). All the trees in one group are tapped on the same day, the men spending very little time in making the incisions and fixing the receptacles. The latex is finally poured and stored in a vessel made to hold from 4 to 8 litres. The men on the following day make new incisions below the old ones and continue the operation for as long as convenient.

METHOD IN THE GOLD COAST.

In the Gold Coast a system rather similar to the full herring-bone is often used, a series of small transverse channels opening into a perpendicular one at the base of which the latex is collected.

MODERN METHODS OF TAPPING.

At the present time the various methods of tapping Para rubber trees may be roughly described as (a) single oblique lines; (b) V-shaped incisions; (c) single cuts with a vertical channel joining them: when the cuts are on one side only of the vertical line, the system is often termed the half-herring-bone, and when on both

* Les Plantes Caoutchouc et Gutta, by Henri Jumelle, Paris, 1903.



A

B

Photo by H. F. Macmillan.

THE FULL SPIRAL SYSTEM.

A.—THE FIRST INCISION. B.—AFTER THE TREE HAS GIVEN 2 LB. DRY RUBBER.

sides the full herring-bone system ; (d) spiral curves. There are various modifications, but they are not of sufficient importance to warrant a detailed separate description.

SINGLE OBLIQUE CUTS.

It should be explained at this point that the laticiferous tubes from which latex is obtainable in large quantities are mainly disposed internally—very near the cambium—and for the most part run through the cortex in a vertical direction.

It should also be remembered that the latex, even when most dilute, is apt to rapidly coagulate on the tree and to form scrap rubber. A cut made horizontally will not conduct the latex to a central point, and horizontal tapping is invariably accompanied by a large proportion of scrap owing to the latex trickling down the stem and drying there. A vertical channel is naturally the best for conducting the latex to a desired point, but it is as extravagant as it is unnecessary in most cases. Parkin proved that simple incisions made in an oblique direction gave about double the yield of latex as either the vertical or horizontal, the latter two showing very little difference in yield of rubber. Each oblique cut may be from one to six or more inches in length, but a distance of nearly one foot apart should be allowed. The oblique incision is practically the basis of most other methods now in use, and is spoken of as the half-spiral system when the incisions are of considerable length.

In this system collecting cups can be placed at the base of each incision, but an invention for conducting the latex from all the incisions to a central basal coil has been brought forward, which, if adopted, might add to the value of this system of tapping.

V INCISIONS.

The V incision is nothing more or less than a duplicated or double oblique system. The sides of each V may be from 2 to 12 inches in length with the apex of the V at the lowest point. The yield obtainable from such incisions is generally, but not always, about double that obtained from a single oblique cut, and having one centre for two incisions seems to be one of the greatest advantages of this system. The V's are usually made on the stem from the base up to a height of six feet, and are distanced about six inches apart. The open end of the V is usually about six inches wide. There is, however, a great variation in the size of the cuts, the smallest incisions measuring about one inch in length.

It has been suggested that the reason why the quantity of latex obtainable is not double that from a single oblique line is because the lines are very close to one another and may draw on the same system of laticiferous tubes, a conclusion which is warranted by the

results of many experiments in various parts of Ceylon. In addition to this drawback there is also another serious result which often accompanies this method of tapping, viz., the loosening of the bark on drying and tapping from the apex of the V upwards.

It cannot be doubted that in a system of small oblique or V cuts a considerable amount of labour is involved in fixing and adjusting a very large number of collecting tins at the base of each incision, and though this system cannot be regarded as drastic and harmful to the tree, it is likely to be superseded by others when planters have to find labour sufficient to regularly tap large acreages of mature rubber. In the oblique or V incisions a chisel or paring knife is commonly used, though most of the implements previously described may be tried in these systems.

In the V method it has been noticed that when the sides of four adjacent V cuts are drawing on an area of 60 to 80 square inches, the flow of milk after two months' tapping becomes very poor. The photograph reproduced on the accompanying Plate shows the V cuts after tapping for ten weeks every alternate day. There was, at the time the photograph was taken, still plenty of space between the adjacent incisions, but the flow of milk was too small to warrant further tapping. This method obviously cannot be carried out for the same length of time as the half or full spiral curves, because the oblique cuts sooner or later interfere with one another and draw on the same limited area. Four trees, tapped similarly by the use of a paring knife and the spur, gave 10 lb. 14 $\frac{3}{4}$ oz. of dry rubber from the 29th June to the 6th September, 1905.

In some countries the exudations from trees are obtained by making incisions in the form of inverted V's, but such a method has no advantage in connection with the tapping of Para rubber trees.

HERRING-BONE SYSTEM.

This consists of a series of short, parallel, oblique incisions connected with a vertical one; the incisions may be on one or both sides of the vertical channel, and vary in length from about 4 to 12 inches. The somewhat diagrammatic illustrations show both systems at the beginning. The vertical channel may vary from 1 to 6 feet in length, and is usually sufficiently wide to conduct the latex from a dozen oblique cuts; the tin placed at the base is the only receptacle for the latex. The advantage of this system lies in the minimum labour required for collecting operations, but there are many reasonable objections against the waste of tissue which occurs when a vertical channel of considerable depth and width is made. Though it is considered to be more drastic than the foregoing method, this system is in use on several estates in Ceylon, and has at times been adopted with success by planters and officials in the Malay Peninsula, India, and Africa.



Photo by H. F. Macmillan.

V. TAPPING.

A TREE AFTER IT HAS GIVEN 2 LB. OF DRY RUBBER.

After the original oblique incisions have been made they are re-opened by paring away the lower surface, this operation being continued until the whole of the tissue between the lines is used up. Any of the knives described may be used for these operations.

When the herring-bone system is used there is no necessity to fix spouts at the base of each incision, as the latex flows down the groove in the bark. Experiments have been made with conducting channels composed of clay, the inner ridge being left open at the base of the incision and the outer one continuous from top to bottom in the half-herring-bone system, and both ridges open at the base of the incisions when the full herring-bone system is adopted; such a channel is easily made, it lasts for quite a long time, and in so far that it does away with the vertical cut in the bark is to be recommended.

The illustrations given here and elsewhere show trees which have been tapped on this system in parts of Ceylon and Malacca.

According to Ridley the tree has, for tapping purposes on the herring-bone system, four sides, and may be tapped along one side only during each year so that operations will be recommenced on the tapping area of 1904 in 1909. This is a very gentle method, and has much in its favour; it can be used to advantage when tapping according to exposure to the sun is adopted.

The zig-zag system of tapping consists of a downward line joining two oblique cuts, on opposite sides but at different levels, and so arranged that the latex is collected at the base of the lowest incision. This system is about the only one that can be recommended for trees which, on account of previous bad tapping, have become gnarled and woody on the surface; the downward and oblique lines can be made of any length and at any angle, and the knots thereby avoided.

It has been pointed out* that vertical incisions lay open very few latex tubes, and must in some degree have the effect of relieving the tension; one may therefore expect a poorer flow of latex from such incisions.

NORTHWAY'S AND BOWMAN'S SPIRAL CURVES.

A third method which, on account of the good yields obtained, attracted considerable attention recently in Ceylon and elsewhere is the long spiral curve. The system consists of a series of parallel cuts running round the stem and each ending separately at the base of the tree; or of shorter cuts ending at convenient places. The number of spiral cuts is determined by the circumference of the tree, there being usually one curve for every girth of 12 to 18 inches at the top of the tapping area. In this method of tapping a series of special knives was used; these ensured the minimum waste of tissue

* M. Henri Lecomte, *Journal d'Agriculture Tropicale*, April, 1902.

when re-opening the lower side of the wound. As this system gave an average of 2 lb. per tree for each month's tapping at Peradeniya, and was continued in some districts until a total of 16 lb. per tree was obtained in twelve months, a detailed description is here given. The illustrations show the stages from the beginning to the end of the first cortical stripping. Spiral tapping is not, however, largely practised in the East.

It cannot be doubted that the full spiral system is drastic, and though excellent yields were once obtained by its adoption it has been realized that cortical stripping should not be effected too rapidly even on old trees. It is the best system to adopt when it is intended to kill out intermediate trees on estates which are too densely planted, and can in such instances be carried out on young trees. The results obtained by this system on 10-to-30-year-old trees at Henaratgoda and Peradeniya appear to justify its adoption on old Para trees, providing the operation is carried out carefully and slowly. The bark on the old trees at the places mentioned was removed at the rate of only *one inch in three months*, and further improvements in the same direction are still possible.

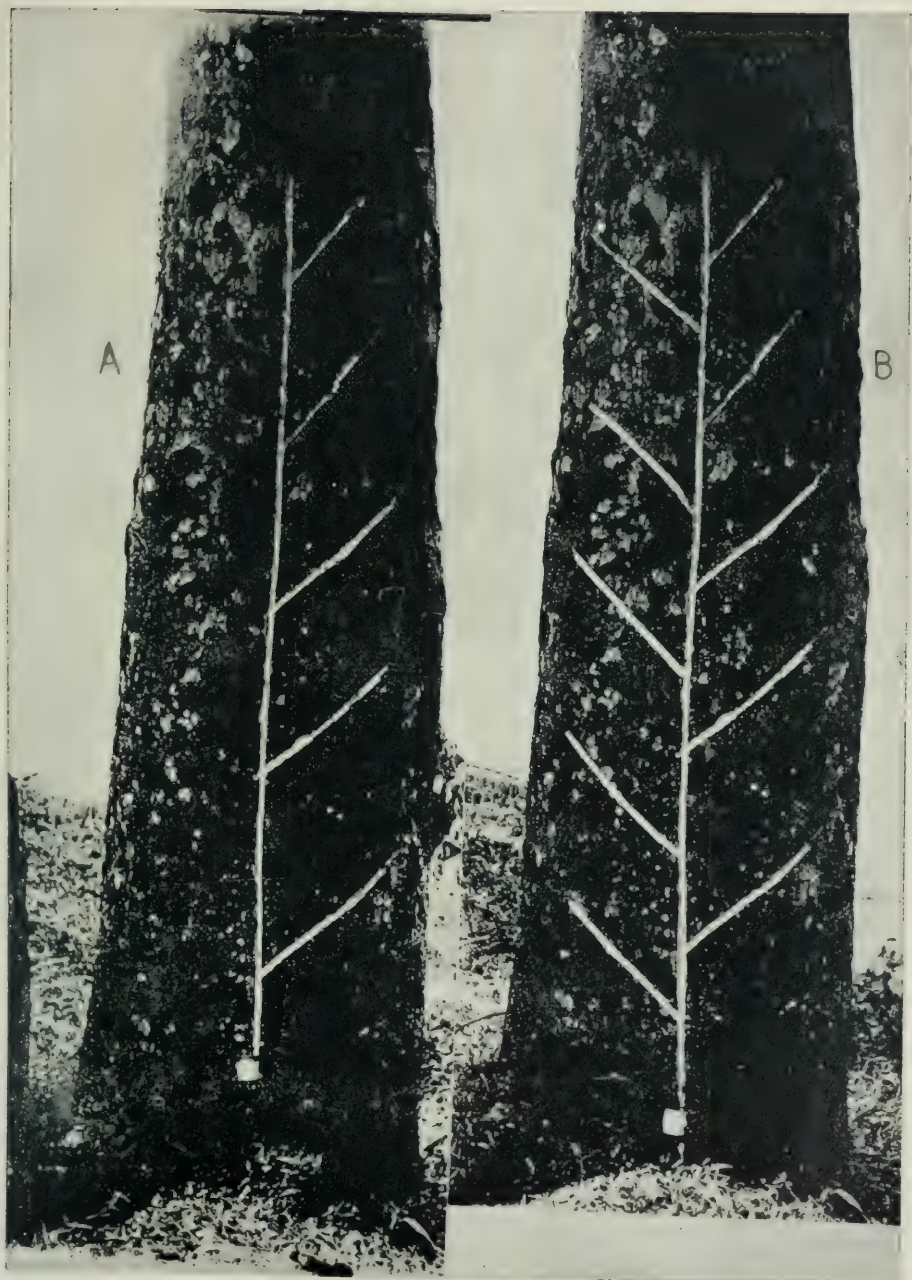
THE SPIRAL SYSTEM AT PERADENIYA AND HENARATGODA.

The spiral system was, in addition to all the foregoing methods, tried at Peradeniya and Henaratgoda with fairly satisfactory results. It will be seen that the yields obtained at Peradeniya were not as large as those reported from other parts of the island; the results at Henaratgoda were good considering the number of times the trees were tapped. The results obtained by different systems at Henaratgoda are given elsewhere, and from them the reader may make his own deductions. The herring-bone and spiral systems allow one to systematically tap the tree from above downwards for one or more years, and to repeat the same operation when convenient. Any system of tapping, which allows the cooly to go over the whole of the bark tissues on a regular plan, is to be preferred to the old V or single short cuts.

I am indebted to Mr. F. Crosbie Roles, Editor of the *Times of Ceylon*, Colombo, for the following description of the method as carried out on a well-known rubber property in the south of the island :—

THE METHOD OF CUTTING.

“The first cuts are made each a foot above the other, and in the case of a tree 18 inches in circumference the groove would go nearly round the stem. For trees 30 inches in circumference two lines of cups on opposite sides of the tree would be required, and a tree 54 inches in girth would take three lines of cups. The first cut is made with a knife used much like a plane; and the second knife is used thereafter day by day for paring off the edge of the groove originally



THE HERRING-BONE SYSTEM.

Photo by H. F. Macmillan.

(A) HALF HERRING-BONE ; (B) FULL HERRING-BONE.

made. One month's tapping with the original knives made the groove two inches wide, so that the whole bark area would be cut away in the course of the year's work, assuming that the tapping were carried on throughout the year in alternate months. The cutting face of No. 2 knife, however, has been reduced to the 16th of an inch. This reduces the bark area cut away in a month from two inches to one inch. A third instrument has been invented for use in this process. It is in the form of a circular pricking instrument, which is used to penetrate to the *cambium* at the edge of the previous cut. This is done alternately with the cutting, and is believed to free the inner bark from any accumulation of latex.

THE YIELD FROM SUCH A METHOD.

"This method was systematically begun in October, 1904, and the group of trees has since averaged over 2 lb. of rubber per tree for each month's tapping, and those trees which have been tapped hardest have produced 16 lb. each in twelve months. Although these trees, like the rest, were tapped in alternate months at first with rest in November and January, they were continuously tapped from February, right through the drought, up to early in June. Then it was found that the yield was falling off, and they were rested for some time. Tapping was recommenced in September. None of them show signs of drooping, and as further token that new and handsome figures in Ceylon yields are not confined to a few trees, records were produced which showed that the whole of the 255 trees on the estate of tappable age had yielded an average of 4 lb. per tree in the eight months, without the trees being harassed. A platform is to be erected round some of the trees for tapping higher up; and an average yield of 3 lb. per tree is expected at from 6 feet to 10 feet from the ground."

The illustrations show at a glance the method adopted; the results obtained, both by the inventor and at Peradeniya, have arrested considerable attention among all cultivators of Para rubber, though the system is by no means extensively adopted at the present time.

THE COLLECTING AND STORING OF THE LATEX.

Having briefly indicated the general principles of tapping implements and operations, it now remains for us to consider the more special contrivances and methods adopted in the process of collecting the latex.

A PROTECTOR.

Mr. A. H. Bury, Ceylon, has devised an apparatus to protect the collecting cups during tapping operations from rain and mechanical impurities. "The protector is to consist of a zinc collar round the trunk of a rubber tree, sloping slightly downwards at an angle approaching 45 degrees. The protector will have a centre edging of felt, fitting on the tree so as to catch any moisture running down

it and allow it to drain off the roof over the latex cup. It will also fasten with a stud fastening, in the same way as an ordinary collar, only there will be several holes on the one end of the collar that fastens over the other, so as to allow of the same sized collar being attached at various times to trees of different girth.*

CENTRALIZING THE LATEX FROM MANY TREES.

On most estates the latex is collected from separate incisions on a tree or from individual trees, an arrangement which will require a very large labour force when large acreages come into bearing. If the trees are regularly planted and the slope of the ground is favourable, there seems to be no reason why a much simpler arrangement for collecting the latex from all or a large number of the trees should not be adopted.

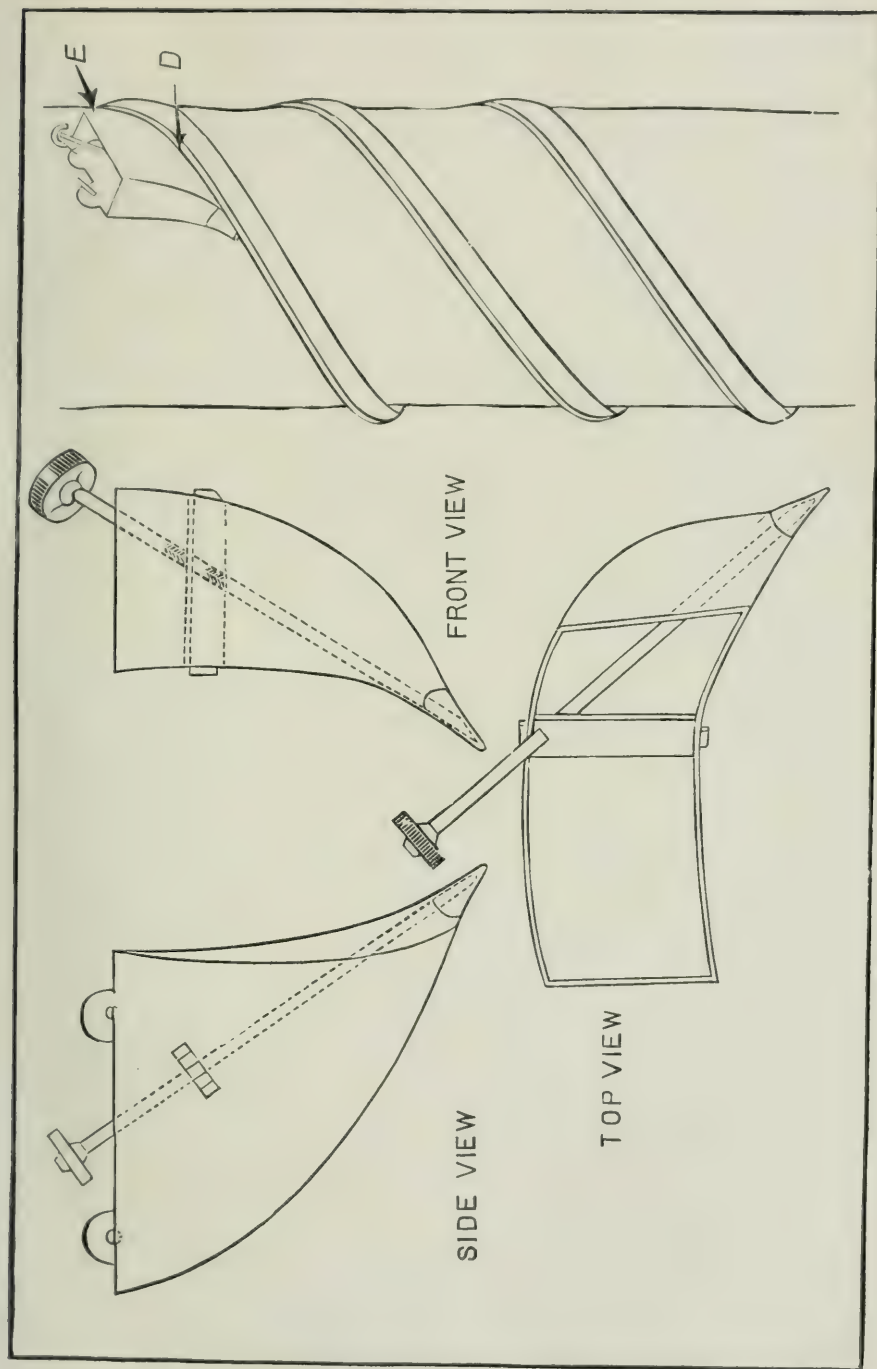
A method has been brought forward having for its object the collecting of the latex from an indefinite number of incisions in one or more trees and conveying it to a common centre, a method which affects the question of labour on large estates. Its complete success depends upon keeping the latex in a liquid condition for a period of time varying according to the distance over which the latex has to be transmitted. The invention is applicable to the V, single oblique, half and full spiral methods of tapping, and in part is applicable to other systems.

Numerous drip spouts made of suitable material are fixed to the base of each incision; the spouts are grooved and of unequal length and are so positioned on the stem as to allow the latex to drip from the upper into the lower spout and finally into a basal coil at the bottom of the tree. The basal coil is grooved and goes completely round the stem at the bottom, and is provided with legs adjusted so as to tilt forward on one side and so allow the latex to escape at a lip or through a hole into a receptacle or conducting channel beneath. By these means it is claimed that the latex from a very large number of trees can be brought to one point, a great advantage in collecting latex from widely distant trees. The method, though ingenious, is not considered practicable. The accompanying illustration shows the arrangement of the various parts.

DRIP-TINS: THEIR CONSTRUCTION AND ACTION.

It is well known to most planters who are tapping Para rubber trees that the latex as it issues from a newly-made incision may vary much in consistency, sometimes being very watery and flowing freely, at other times being too thick to trickle along the lines prepared for it. In high tapping the latex may have to traverse a distance of over twenty feet along the stem before it reaches the receptacle at the base and in many instances never succeeds in

* *Ceylon Observer.*



Lent by G. S. Breen.

DRIP TINS: THEIR CONSTRUCTION AND APPLICATION.

being collected except as scrap rubber. Furthermore, the latex during the periods of drought does not run as freely as when the moisture conditions are more favourable.

In all such instances the latex tends to coagulate on the tree and is subsequently collected as scrap. An attempt has been made to overcome this difficulty by the use of a receptacle called the drip-tin. This consists of a tin vessel made to hold a known quantity of water and ammonia or water and formalin. It has a concave surface to fit the convex outline of the tree and is fixed to the bark by means of pins. At the base it is drawn out to a fine point, which, when the drip-tin is adjusted, is in contact with the tapping area on the stem. The point is provided with an ingenious screw arrangement by means of which the drops of liquid allowed to issue can be regulated according to requirements. The apparatus is placed at the top of each incision, and as soon as the tree has been tapped the drip is allowed to commence. By these means the latex is to a great extent prevented from drying up on the stem and is carried rapidly towards the base; the latex tubes not being blocked by the coagulated substances continue to give forth the latex for a long period. It is claimed that this invention will greatly reduce the amount of scrap, and that the laticiferous tubes are more nearly emptied by its adoption.

It is certainly an advantage to be able to secure, when necessary, the latex in such a state that it will remain in a liquid condition until the formalin or ammonia is driven off. The accompanying sketches show the essential parts.

The above refers to the more complex type of drip-tin, but several others designed on an improved and simpler plan and more suitable for coolies have already been made in Ceylon. They are useful but not largely adopted in the East.

KEEPING THE LATEX LIQUID AND SETTLING TANKS.

On small estates where few and widely-scattered trees are being tapped the planter is often compelled to resort to the production of rubber on a small scale; this frequently involves a daily repetition of the same process and much petty hand labour. The latex can, however, be kept in a liquid condition for several days or even weeks, without doing much harm to the finished product, and the rubber can be manufactured on a big scale when a sufficient quantity of latex has been accumulated.

The latex can be kept in the liquid condition by the addition of ammonia, formalin, sodium carbonate, or any alkaline chemical which is readily soluble in cold water. It is better to use either ammonia or formalin and to avoid any of the mineral salts; the former can be readily removed and may even escape on exposure to the air in the ordinary processes of preparation.

In one invention, patented by Brown, the latex is kept in covered settling tanks supplied with (1) a drip-tin apparatus filled with chemicals to retain the milk in an alkaline condition, and (2) with a paddle to keep the latex in motion. If a receptacle containing ammonia is exposed to the air, the reagent will evaporate and the latex coagulate within a few days. If, however, the receptacles are covered or sealed, the ammonia cannot easily escape and the latex can be accumulated in a liquid state indefinitely.

Formalin has a similar effect, as it stops putrefaction and therefore prevents the development of acidity. The ammonia probably neutralizes the acids as they are formed and thus maintains the latex in an alkaline or neutral state, thereby preventing the precipitation of the proteid matter. By the use of such reagents and apparatus a great saving of labour may be effected

The Editor of the India-Rubber Journal has recently reviewed a translation of a privately circulated French pamphlet, on the subject of exporting the latex in a liquid condition in order to allow the manufacturer to prepare his materials at the first coagulation.

NORTHWAY'S AND BOWMAN'S SYSTEM OF MARKING THE TREES.

The system consists first in marking out the grooves at the correct distance and angle they are to be cut during tapping. This is effected by means of a guide in the shape of a right-angled triangular piece of tin, the side subtending the right angle being 2 ft. in length, and the other sides 17" by 17". The hypotenuse is the line along which the trees are marked, one of the 17" sides being arranged vertically before marking is commenced.

The grooves to be cut along the sloping side or hypotenuse of the triangle will then be at an angle of 45 degrees to the base, each groove 2 ft. long and at intervals of one foot, starting one foot from the base of the tree, up to a height of 5 ft., and all leading into a vertical channel running down to within a few inches from the ground-level. A small tin spout is inserted at the lower end of the vertical channel to convey the latex into the tin vessels, which are placed on the ground near the tree. The tin spout is left in position permanently, thus obviating the necessity of constantly inserting cups into the bark and removing them, and at the same time avoiding injury to the tree. In the case of a tree 18" in circumference, the grooves would go nearly once round, and therefore for trees of this size there would be one vertical channel to convey the latex flowing from the several spiral cuts into the tin receptacle, and only one of the latter would be needed. A tree 36" in circumference would require 2 vertical channels on opposite sides of it, and correspondingly a tree 54" in circumference would take 3 vertical channels, each leading into a tin receptacle placed on the ground as previously stated. To suit trees of various sizes and



Photo by Ivor Etherington.

DOUBLE AND MULTIPLE DRIP-TINS.

ONE DRIP-TIN FOR TWO OR MORE TAPPING LINES.

DRIP-TIN PERMANENT! CONDUCTING STRING ADJUSTABLE.

yielding capacities, the grooves can be made longer or shorter as may be found necessary or convenient. One month's tapping with certain knives would carry the grooves down about one inch so that tapping on and off, one month at a time, the whole space between the top and bottom grooves would be covered in the course of two years' work. The operation is carried on continuously, so that at the end of each period of two years only the original top cut would have to be re-tapped, the lower cuts being made into the sections below when the bark tissues have been completely renewed.

Mr. Francis Holloway has also given me particulars of his method of marking the trees. A long rod, marked off into feet, is placed against each tree. A sheet of zinc or tin, cut at a certain angle (about 45°), fits at one end into the rod, and can be moved up and down as desired. The remaining part of the zinc or tin ribbon is then wound round the tree and the markings made. The rod, being marked into distances of one foot, can be used at any height on the trunk, the spaces between the oblique tapping markings being in every case parallel and distanced one foot from each other. This plan can be adopted for marking out spiral curves or oblique incisions, and is therefore applicable to the herring-bone system.

COLLECTING TINS.

Tin or iron receptacles for collecting the latex are not so good as enamelled ones or those made of aluminium, as they are apt to corrode on exposure and to lead to a discolouration of the rubber, when the latex contains large quantities of tannin. In all methods, except the herring-bone and spiral systems, it is necessary to fix the tins on the trees and therefore to have some sharp point to press against the bark for fixing. Where the herring-bone or spiral systems are in vogue, a permanent channel is fixed at the base of each line and the tins placed on the ground immediately under the channel; the latter arrangement is found to be economical.

The advantages and disadvantages of the various systems, and the effect of tapping on the quality of the latex, will be discussed later.



CHAPTER VIII.

WHERE TO TAP.

Occurrence of latex in parts of the plant—Rubber from young parts of trees—Tapping virgin and wound areas—Wound response and increased yields at Peradeniya, Java, and the Straits—Interval between successive tappings and wound response—Arden's results—Clotting of rubber in convex wound areas—Method of formation of Para milk tubes—Best yielding areas—Results of experiments from the base upwards in the Straits and Ceylon—Illustration showing tapping from 6 to 16 feet and base to 50 feet at Henaratgoda—Yields obtained from various levels at Henaratgoda—Latex from high parts of old trees—Occurrence of non-coagulable latex.

IT is wellknown that in the Para rubber tree the latex occurs in all parts of the stem and branches and in the leaves. But the quality and quantity of the latex in the leaves, young twigs, and branches are such as to render the collection from these areas unremunerative. The more or less successful production of gutta-percha from leaves led many to anticipate that rubber might be obtainable from the foliage and young twigs of *Hevea brasiliensis*. "The latex in young stems* and leaves does not freely ooze out and mix with water, but clots where it exudes in little lumps, which cling to the broken pieces of stem." The rubber from these tissues is adhesive and has less elasticity and strength than the rubber from the trunks of mature trees. It may be safely asserted that the collection of latex from this species must be made from the stem, and in some cases perhaps the main branches, and that all other parts may be neglected as sources of paying quantities of marketable rubber. In practice it is easier to tap the stem from six feet downwards than any other part, though the erection of stands, scaffolding, and the use of ladders and walking stilts for tapping higher parts and thick branches have been tried with successful results. Estates are known where rubber in paying quantities has been obtained from six to twenty feet, but tapping above six feet is not generally adopted. The fact that a maximum of 10 to over 20 lb. of rubber per tree has been obtained from the lower part of the stem alone within twelve months from commencing tapping operations makes it very doubtful whether tapping of less accessible parts will come into general force. The strain on the plant to heal the wound area from six feet downwards is quite as much as it need stand.

* Parkin, *l. c.*

Furthermore, it must be remembered that the maximum quantity of latex and rubber may be obtained not so much by tapping virgin areas as by taking advantage of the wound response and pricking or cutting the laticiferous tubes when they contain the maximum amount of latex.

THE WOUND RESPONSE.

It has been stated that native collectors of Para rubber do not attempt to gather the latex from the first incisions, and that a quantity capable of being collected is only obtained after two or more tappings in approximately the same area. It is certainly not advisable to make the first incision so deep that a good flow of latex is obtained at once; only small quantities of latex should be expected from the original incisions. The first cuts can be deepened as necessity determines in subsequent tapping operations. The flow to the injured part increases gradually, and may reach the maximum after three to fourteen tappings, after which it is said to decline if the wound area is continuously tapped. The first reliable results were obtained by Willis and Parkin, and as the "wound response" is now recognized as one of the most important principles in determining the frequency of tapping, the following digest of Parkin's results is given:—

Number of Tappings.		Number of Incisions.		Date of Tapping		Yield of Latex in c.c.
1st tapping	..	40	..	March 25	..	61·0
2nd "	..	40	..	" 30 ₄	..	105·5
3rd "	..	40	..	April 6	..	220·0
4th "	..	40	..	" 12	..	208·5
5th "	..	40	..	" 15	..	255·5
6th "	..	40	..	" 20	..	290·0
7th "	..	40	..	" 25	..	276·0
8th "	..	40	..	May 1	..	253·0
9th "	..	40	..	" 6	..	264·5
10th "	..	40	..	" 13	..	275·0
11th "	..	40	..	" 20	..	255·0
12th "	..	40	..	" 26	..	262·0
13th "	..	40	..	June 1	..	328·0
14th "	..	40	..	" 6	..	449·0

The increase in yield from 61 to 449 c.c. of latex by repetitional tapping in approximately the same area is little less than wonderful, and it now remains to determine the interval which must be allowed between successive tappings. The wound response is not evident twelve hours after tapping, but within twenty-four to forty-eight hours it is decidedly obvious. These results suggest the advisability of every planter carrying out his own experiments to determine whether it is better to tap every day for the half of each month, alternate days during each month, or only during certain months. Tapping every day, either for the whole of the months when rain was abundant or only during alternate months, has already given

excellent results on a large scale on several estates in Ceylon. The nature of the origin of the latex tubes in *Hevea brasiliensis* accounts, to some extent, for the variation in yields from the same area; the tubes require a certain time to complete their formation, and for this reason areas which do not yield any latex on particular days may give abundant flows subsequently, when the processes of perforation and decomposition are sufficiently advanced.

In Java, Haas* has proved that wound response occurs in the Para trees in that island. He also points out that an increase in the number of incisions increases the yield of rubber, but not in the same proportion, and states that an increase of 25 grammes of rubber per square metre of tapped surface is only obtained after more than doubling the number of incisions.

WOUND RESPONSE IN 24 HOURS.

Arden concluded from the following experiments that the length of time which should elapse before re-opening incisions need only be 24 hours, and that tapping every alternate day instead of daily was not always advisable. The following were his results:—

60 incisions made on six consecutive days gave 99½ oz. wet rubber					
60	„	at intervals of two days	„	111	„ „
60	„ „ „ „ „	one week	„	104¾	„ „

In the Peradeniya experiments where the spiral system has been used, it has been noticed that the renewed cortical tissue becomes more or less convex in outline. In some instances clots of rubber were found beneath the bulging areas, and from microscopic examination it was concluded that the convex outline was due, to some extent, to the abnormal rapid distension of the cells of the newly-formed tissue; the coagulated rubber seemed to arise by the bursting of the inflated tubes. This was “wound response” to a remarkable degree, and on all such areas the use of Bowman’s and Northway’s pricking instrument gave abundant flows of latex.

There is a certain amount of reason in tapping any yielding area of the stem and branches, on account of the peculiar manner in which the latex tubes are produced and their connection with one another. The tubes in Para rubber are produced by the breaking down of the partition walls of adjacent cells or sacs, and the final tubes may be very short or long according to the age and the number of partition walls which have been dissolved. The tubes arise *de novo*, and in tapping operations one does not necessarily drain the latex from all parts of the tree, but very often only from one or two inches around the incision, where latex tubes have been formed.

* Results of experimental tapplings of *Hevea brasiliensis*, Java, 1900-1904, by Dr. W. R. Tromp de Haas. (Vide Bulletin of Straits & F.M.S.), August, 1905.

BEST YIELDING AREAS.

Experiments to prove which is the best area to tap have been carried out by many observers. The larger flow at the base of the trunk than from higher parts has been noticed by Parkin and others in Ceylon, by Seaton in India, by Haas in Java, by Arden in Malaya, as well as by native collectors in the Amazon valley. It is on account of this that the idea of increasing the lower tapping area, by pruning the young plants and retaining a few of the basal shoots to grow into leaders in after years, is often recommended, for instead of one stem there might be two or three available for tapping. If only one stem is retained, it will show a large increase in circumference.

RESULTS OF EXPERIMENTS REGARDING QUALITY AND QUANTITY.

Experiments in Malaya.

The following experimental tappings by Burgess* indicate the quality of the rubber from different parts of the plants:—

Position of the Cut.	Nature of Cut.	Percentage of Crude Rubber in Latex.	Percentage of Resin in the Crude Rubber
1. A large root exposed by removal of some soil.	Simple three-inch cut.	43·8	2·27
2. The main trunk 1·2 feet above the ground.	Herring-bone.	44·4	2·12
3. The trunk after forking 20 feet above ground.	Herring-bone.	39·8	1·88

“It will be noted that the latex from the higher portions of the trunk are, in the above experiments, poorer in rubber than the latex from lower down—at the same time the proportional amount of resin in the latex appears to decrease.”

The following experiments† indicate that the lower part up to 98 cm. (1 cm. equals to 0·39 inch) yields considerably more rubber than the higher parts:—

Number of Incisions.	Area tapped.	Yield of Latex in grammes.
120 ..	0 to 60 cm. ..	2226·44
100 ..	60 to 120 cm. ..	1111·09
120 ..	120 to 180 cm. ..	587·43

* Burgess in Agricultural Bulletin of the Straits & F.M. S., May, 19 04
 † L' Hevea Asiatique, M. Collet.

These results show that the maximum yield, per given area, is to be obtained from the base up to a height of about five feet. Other experiments have proved that the yield from the base to three feet is considerably more than that from three to six feet.

EXPERIMENTS IN CEYLON.

Experiments carried out in Ceylon * strongly support the same conclusion, and the following are typical examples of the results obtained :—

	Number of Incisions.		Area tapped.		Yield of Latex in c.c
A	{ 26	..	12 inches from base	..	24·5
	{ 26	..	36 „ „	..	18·0
	{ 26	..	72 „ „	..	18·5
B	{ 14	..	At base of trunk	..	30
	{ 14	..	At 48 inches from base	..	14
	{ 14	..	At 108 „ „	..	11·5

The conclusions which Parkin drew from his experiments were “that there is a greater exudation of latex from wounds made at the base of the trunks of Hevea trees than at any higher region; that the exudations from one to five or six feet up the trunk differ little; and that above five or six feet the latex exuded falls off very considerably.” Experiments in the Straits have shown that the first four feet from the base contain the maximum amount of latex, but a height of six feet is allowed by many planters. It is wellknown to planters in Ceylon that the quantity of latex obtained at five to six feet from the ground is little more than half that at the base of the trunk; nevertheless, a yield of over 1 to 3 lb. of rubber, per tree, is expected on certain estates by tapping the area from six to ten feet above ground. The latex obtained from areas twenty feet from the base is often very sticky and may not yield good rubber, but this is by no means always the case. On some estates in the Ambalangoda, Kalutara, and Matale Districts the old rubber trees are said to give latex of good quality from six feet upwards.

According to Dr. Haas, the trees in Java gave the largest yield in their lower parts, and tapping up to a height of 1·5 metre gave the best results.

TAPPING THE HIGHER PARTS OF TREES.

Base to 50 feet.

As previously indicated, it is possible to obtain rubber in paying quantities from parts of the stem above six feet. At Henaratgoda the trees have really never been cultivated, and many of them,

* Parkin, *l. c.*, pp. 128 and 131.

HIGH TAPPING AT HENARATGODA.

1.



2.



Photo by H. F. Macmillan.

TAPPING FROM BASE TO 50 FEET.

TAPPING FROM 6 TO 16 FEET.

though thirty years old, have never been tapped. The result is the stems are very high, and present smooth surfaces such as one would desire for ideal tapping operations. Such trees are occasionally found on a few rubber properties in Ceylon, the Straits, and elsewhere, but it is not likely that similar development will be allowed on rubber properties now being planted. Generally speaking, the planters who are laying out their estates desire to obtain some return as early as possible, and their object will probably be to prevent the production of tall heavy timber trees and to accentuate the growth of the lower part of the stem up to 15 to 20 feet, in order to secure the minimum girth required for commencing tapping operations.

It is for this reason that the following results should not be taken into too serious consideration, as they have been obtained from the old and previously untapped trees at Henaratgoda. In the Henaratgoda experiments the trees have been tapped at various heights: (1) from the base to a height of 5 and 6 feet; (2) from 6 to 16 feet only; (3) from 10 to 20 feet; (4) from 20 to 30 feet; (5) from the base to a height of 30 feet; and (6) from the base to 50 feet. The following are the details of the experiments and the results obtained up to date:—

	No. of Trees.	No. of Times tapped.	Excised Area. sq. in.	Weight of Dry Rubber obtained. lb. oz.
Base to 5 and 6 feet	25	..	37 .. 12,414 $\frac{3}{4}$	.. 50 0 $\frac{7}{8}$
6 to 16 feet	..	2 ..	16 .. 796 $\frac{1}{2}$	.. 4 10 $\frac{5}{8}$
10 to 20 feet	..	2 ..	16 .. 1,472 $\frac{1}{2}$	.. 6 9 $\frac{1}{4}$
20 to 30 feet	..	2 ..	16 .. 1,424 $\frac{3}{4}$	.. 4 11 $\frac{1}{2}$
Base to 30 feet	..	1 ..	23 .. 1,666	.. 4 6 $\frac{3}{8}$
Base to 50 feet	..	2 ..	8 .. 2,726	.. 3 4 $\frac{1}{4}$

The higher parts of such trees can be tapped alternately with the lower parts, but how long this can be continued it is impossible to say at the present time. The illustrations show one specimen tapped from the base to a height of about 50 feet, and another being tapped from 6 to 16 feet from the base.

The amount of labour involved in tapping such large areas on a large number of trees is beyond comparison with that required for the ordinary basal and more accessible tapping.

LATEX FROM HIGH PARTS OF OLD TREES.

It has been previously pointed out that the cortex of the seedlings of *Hevea brasiliensis* and the cotyledons of the seed itself possess a large number of laticiferous channels, but the latex obtainable therefrom is usually very sticky and the dried product of low commercial value. Rubber prepared from two-year-old trees of *Hevea brasiliensis* is sticky and easily snaps when lightly stretched;

that from four-year-old trees or from stems which have a circumference of about twenty inches, though it does not possess the properties which manufacturers most desire, realizes a price which is, to the producers, satisfactory. When a tree is tapped for the first time, though it may be from 4 or 29 years old, the rubber obtained from the latex is apt to turn soft, sticky, or tacky, on keeping.

OCCURRENCE OF NON-COAGULABLE LATEX.

Ordinary tappings of medium-sized and old *Hevea* trees usually give good rubber when the tapping operations are carried out on the basal part (base to 5 or 6 feet); it is curious, however, to note that when the higher parts of even the oldest trees in the East are tapped the latex obtained often appears to be changed in constitution. The latex from high parts of very old trees is often very watery, and possesses a low percentage of caoutchouc; on treatment with the requisite quantity of acetic acid, coagulation does not take place; even when allowed to stand for several days a curdled liquid only is obtained, the particles of which are not elastic and do not adhere to one another. The following results * were obtained in Ceylon :—

Height of tapping area.	Number of times tapped.	Number of times when latex not coagulable.	Per cent. of tappings giving non-coagulable latex.
Base to 5 or 6 feet	1,165	9	0.77
„ 6 to 16 „	95	1	1.05
„ 10 to 20 „	94	1	1.06
„ 20 to 30 „	94	2	2.12
„ 30 ft.	171	24	14.03
„ 50 „	84	5	5.95

The number of times when non-coagulable latex has been obtained from various sections of the stem of 29-year-old trees is given in the table; in considering them one should remember that the circumference of the stems at the highest points tapped was not less than 30 inches. It will be obvious that this phenomenon was most frequently observable in connection with the latex secured when tapping from the base to a height of 30 and 50 feet.

* Rubber Cultivation in the British Empire; Messrs. Maclaren and Sons, Shoe Lane, London, 1907.



Photo by M. Kekeay Bamber.

PARA RUBBER IN CEYLON.

AMBALANGODA DISTRICT.

TWO-YEAR-OLD PARA RUBBER TREES.

CHAPTER IX.

WHEN TO TAP.

Age or size as criterion—Resin in young trees of *Castilloa* Rubber—Analyses of rubber from 2, 4, 6, 8, 10—12, and 30-year-old Para rubber trees—Two-year-old tree illustrated—Age of tapping trees in the Straits—Age of tapping trees in Malacca—Age of tapping trees in Ceylon—Age and size considered—A manufacturer's opinion of rubber from 8-year-old trees—Minimum size for tapping—How to increase the tapping area illustrated—Measurements of forked and straight-stemmed trees at Henaratgoda—The best season for tapping—Tapping during period of rapid bark renewal—Atmospheric conditions and the flow of latex—Results in Strait Settlements, Ceylon, Java, F. M. S. and Nicaragua—Results of Ridley, Haas and Arden—Latex flow during the leafless phase—Use of ammonia and formalin—What part of the day to tap—Yields in morning and evening—Compass tapping—Frequency of tapping and results at Henaratgoda—Yields obtained by tapping every day, every alternate day, twice per week, once per week, once per month—Frequency of tapping on Vallambrosa Rubber Estate—Frequency when tapping young trees on Lanadron Estate.

IN discussing this part of the subject it is necessary to take into consideration the age and size of the tree so as to determine when it may be tapped for the first time

Several botanists have argued the question, and as it is one which concerns the quality and quantity of the latex and the dimensions and physical condition of the tapping area, it needs to be considered carefully.

IMPORTANCE OF AGE.

Ule and Seeligmann state that in the Amazon District the tree requires 15 years to come to tapping maturity in open plantations and 25 years in the forest, and one cannot help concluding from this statement that either the cultivated plants in the East thrive much better in their land of adoption than the wild ones in their native habitat, or that the collectors are less eager to commence tapping operations in the Amazon District than in Ceylon and Malaya.

Cross stated that in Para the trees were tapped if they had a circumference above 18 or 24 inches, the operations being carried out until the trees were killed. On plantations in the East such dimensions may be attained in four to six years.

Trimen, in 1884, believed that the trees in Ceylon should be ten years old before commencing tapping operations.

Johnson is of the opinion that the size, and not the age, of the tree indicates when it can be safely tapped, and that tapping may be commenced when a tree has a girth of 20 to 24 inches a yard from the ground.

ANALYSES OF YOUNG CASTILLOA RUBBER.

If one studies the many analyses of *Castilloa* rubber quoted by Weber and the publications of the West Indian Botanic and Agricultural Departments, he cannot help being struck with the fact that the quality of the rubber from *Castilloa* trees depends, in almost every case, on the age of the trees. In some cases the rubber from old trees is shown to contain 82.6 per cent. of caoutchouc and 7.4 per cent. of resin. The rubber from four-year-old *Castilloa* trees has been shown to contain 64.1 per cent. of resin as against 8.2 per cent. for twelve-year-old trees.

The importance of age is further exemplified by analyses showing a gradual decrease in percentage of resinous substances, which occurs with an increase in the age of the part of the *Castilloa* tree from which the rubber is obtained, the young twigs yielding 5.8 per cent., the large branches 3.77 per cent., and the main trunk only 2.61 per cent. of resinous substances. If the rubber contains a very high percentage of resin, it is usually considered inferior, and is in some cases almost useless. Increase in age is certainly to be associated with an improvement in the physical properties and quality of the rubber, whether one considers plantations of different ages or parts of the same tree.

ANALYSES OF PARA RUBBER FROM DIFFERENT AGED TREES.

	2 yrs. old.		4 yrs. old.		6 yrs. old	
Moisture ..	0.70%	..	0.65%	..	0.55%	
Ash ..	0.50	..	0.30	..	0.40	..
Resin by acetone ex- traction ..	3.60	..	2.72	..	2.75	..
Proteins ..	4.00	..	1.75	..	1.51	..
Rubber ..	91.20	..	94.58	..	94.79	..
	<hr/> 100.00		<hr/> 100.00		<hr/> 100.00	
Resins extracted by glacial acetic acid...	2.74%	..	2.62%	..	2.65%	
	8 yrs. old.		10-12 yrs. old.		30 yrs. old.	
Moisture ..	0.85%	..	0.20%	..	0.50%	
Ash ..	0.14	..	0.22	..	0.25	..
Resin ..	2.66	..	2.26	..	2.32	..
Proteins ..	1.75	..	2.97	..	3.69	..
Caoutchouc ..	94.60	..	94.35	..	93.24	..
	<hr/> 100.00		<hr/> 100.00		<hr/> 100.00	
Nitrogen ..	0.28%	..	0.48%	..	0.59%	

The above analyses* show the chemical composition of Ceylon-grown Para rubber prepared from trees varying in age from 2 to 30 years. It will be noticed that the two-year-old rubber does not differ conspicuously from the older mature rubber. The analyses represent the composition of only one series of samples, and should not be taken as showing the constant composition of rubber from trees of the ages quoted. The rubber from two-year-old trees was sticky, and snapped when slightly stretched; it was obviously unfit for sale. The illustration here reproduced, shows the tree from which the rubber was obtained; it is perfectly clear that the available tapping area on such trees is very small.

Parkin proved that the preparation of good rubber from young stems and leaves of *Hevea brasiliensis* was an impossibility, and other observers have shown that rubber from young trees is adhesive and lacks the required elasticity and strength; nevertheless, it is still the subject of much discussion as to whether age is the only criterion for cultivators of Para rubber in the East.

Stanley Arden has shown that in parts of Malaya the rubber from trees $3\frac{1}{2}$ to 4 years old is decidedly inferior. His results have been quoted in the section dealing with "Yields of Rubber," and it is only necessary to point out that the yield from trees up to four years old was exceedingly small, and that rubber in paying quantities was only obtained when the trees were about or over seven years old. He calculated that by the time the trees in Malaya are six years old, 75 per cent. should give an average yield of 12 ounces.

On certain Malacca rubber properties the Para rubber trees, even though catch crops have been taken off the ground during the first few years, attain in four years a circumference of 18 inches, and in seven years 35 to 40 inches. These trees are planted 15 feet apart and can be very lightly tapped after the fourth year.

Samples of Para rubber from four-year-old trees have, however, been deprecated in certain quarters, and in one case they were classed as being similar to common African† sorts for hardness, but superior in cleanliness. They were described as being soft, and would not stand much working on the machine, while the value put upon them was only equal to that for "Congo ball or a similar quality of African."

AGE AND SIZE.

With regard to our experience in Ceylon it should be pointed out that under favourable circumstances the Para rubber tree will

* Committee of Agricultural Experiments, Peradeniya; M. Kelway Bamber.

† India-Rubber Journal.

show an increase in circumference of about 4 to 5 inches per year up to the first six or eight years, and that though the rubber from two- to six-year-old trees is adhesive, and may have a high percentage of resinous compounds, it is by no means always the case. The analyses of Para rubber from 2-, 4- and 6-year-old trees have been previously given, and though the results cannot be accepted as conclusive, it was pointed out by Mr. Kelway Bamber* that the rubber did not possess a very high percentage of resin, and in this respect was certainly quite contrary to what Weber and others have observed in the rubber from young *Castilloa* trees. But when one considers that the rate of growth of the Para rubber tree in Ceylon is such that a circumference of 20 inches cannot be attained much before the fourth, fifth, or sixth year, it is obvious that, under ordinary methods of cultivation, all ideas of extracting rubber from trees under these ages should not be encouraged.

One manufacturer is reported† as saying that the rubber does not attain its full strength until the tree is at least 8 or 9 years old, and material from younger trees "has not the strength of hard cure Madeira fine Para, and is uneven in strength." It is also asserted that there is no difference noticeable in the rubber from 8-year-old trees from different plantations, but it is not yet safe to use it for the finest work, such as thread and the best bladders.

MINIMUM SIZE FOR TAPPING.

If the tree has a circumference of much less than 20 inches, tapping cannot be recommended, because the available tapping area is too small; nevertheless, on several estates the trees having a circumference of only 15 to 18 inches are tapped. The production of new tissue would be a strain on the young plant, and the thin bark tissues would probably be quickly cut away long before the desired quantity of rubber had been obtained.

If the circumference is anything above 20 to 24 inches, a yard from the ground, and the tree is four to six or more years old, it can, in Ceylon, be lightly tapped. I have seen good rubber from such trees. A tree 24 inches in circumference cannot have more than two spiral curves for tapping; it could be tapped on the herring-bone system on one or both sides of the tree.

On one estate in Ceylon 41 trees of considerable height, but having a circumference of from 18 to 25 inches a yard from the ground gave with very light tapping during March and April 19½ lb. of dry rubber, which was favourably reported upon in Europe.

From the foregoing remarks it is clear that the questions of available tapping area and age cannot be neglected; they are as

* Committee of Agricultural Experiments, Peradeniya. M. Kelway Bamber.

† India-Rubber World, December, 1905.

important as the ages of the trees. A minimum circumference of 20 inches, a yard from the ground, and a minimum age of 4 to 6 years can be accepted for most rubber properties, the better developed trees being tapped first.

HOW TO INCREASE THE TAPPING AREA.

The foregoing statements refer to trees of known ages that have attained the minimum circumference when allowed to develop very long and slender stems. But it has been previously remarked that by pruning the trees at a certain stage the plant may be made to increase in girth at the expense of the longitudinal growth, and a very striking illustration is to be seen in the first clump of old Para rubber trees in the Henaratgoda Garden, Ceylon. The dimensions of forked and straight-stemmed trees on various estates in Ceylon have been previously given.

In the particular group referred to the majority of the trees have long straight stems, unbranched to a height of 30 to 60 feet. But in addition to these there are a few which, from some cause or other, have forked at from 7 to 11 feet from the ground, and in all these cases the trunks are conspicuously larger in circumference and therefore present an increased tapping area. The following are the dimensions of some of the low-branched and straight-stemmed trees :—

Henaratgoda Trees.

Circumference of trunk, in inches, a yard from the ground.

Trees with long straight Stems. Inches.	Tree forked at 11 feet from Base. Inches.	Tree forked at 7 feet from Base. Inches.	Tree forked at 9 feet from Base. Inches.
61, 65, 83, 85, 76	109 ..	104 ..	109

In all instances those trees which have forked near the ground have a much larger basal circumference.

It does not need any argument to prove that an increase in circumference of over 30 inches is an advantage, and the fact that such an increase has occurred in the tapping areas of trees about 30 years old is sufficiently encouraging to tempt the planter to carry out a few bud-pruning experiments, once his trees have attained a height of about ten to twenty feet. The buds which appear in undesirable places can be removed by "thumb-nail" pruning. Experiments have been made with young trees in their first and second years, and in each case the increased rate of circumference has been obtained in trees within the second year. In dealing with young plants it is an easy matter to nip off the terminal bud of the main stem, when the desired height has been obtained; this is usually followed by the development of

lateral shoots, the growth of which should be encouraged according to circumstances. An increase in the number of lateral shoots means an ultimate increase in the foliage, and it is on this point that the success of the work depends. The pruning should be carried out in such a manner that the resultant plant has an increased quantity of foliage, whereby a larger food supply can be built up for the benefit of all parts of the tree. If the work is done in such a manner as to deprive the plant of its leaves for a long period of time, the growth of the stem will be temporarily checked, and the immediate increased rate of growth of the stem tissues cannot be expected.

THE BEST SEASON TO TAP.

The Para rubber trees in Ceylon drop their leaves in February or March, produce new leaves and flowers after a leafless phase of a few days or a couple of weeks, and yield ripe fruit in August and September. There is an active vegetative period from September to December; a short, marked, resting period in February; and a floral and foliar condition from February to September. The climate during these months has been dealt with in Chapter III.

The trees of *Hevea brasiliensis* exhibit a definite foliar flower and fruit periodicity, and though they will stand tapping throughout the year it is questionable whether periodicity in tapping should not be done in association with that of the plant. The trees should be tapped at a time when the bark is most quickly renewed in order that cortical tissues may be formed wherein new laticifers can be produced. The periodicity of the trees varies according to climatic and other factors, but the period including the fall of leaf, the leafless phase, and that of foliar renewal appears to be the most critical one. In most parts of the Straits Settlements, according to Ridley, from December to March is probably the resting or relatively inactive period and the bark renewal during these months cannot take place as rapidly as during the rest of the year. On a large estate every planter is aware of the fact that it is impossible to entirely suspend tapping operations during any month of the year, but the above consideration should, whenever practicable, be allowed for.

Several writers have associated the yield of latex with atmospheric conditions, the general contention being that a low temperature in the tropics and plenty of moisture were conducive to a copious, and more or less continuous exudation of latex. During hot dry weather the amount of water lost by transpiration from the leaves is very great, and it has been argued that this loss reduces the tension in the cortex and therefore in the latex tubes; hence the poor flow obtained during such times.

Dr. Haas, as a result of his experiments in Java, concludes that if the humidity of the soil is great, and if the rains are equally distributed, the difference in yield during the year is not great, and he

further states that though the best times for tapping, in Java, are at the beginning and the end of the wet season, in wet years it does not matter when the trees are tapped.

In parts of the F. M. S., where the climatic periodicity is not so strongly marked as in Ceylon and South India, there is said to be but little variation in the yield of rubber during different months.

"Mr. Larkin, whose estate at Castlewood* I have recently visited, tells me that during the late dry month of March all his trees in one part of the estate shed their leaves simultaneously, and remained bare for a time. He continued to tap during this period, and found no diminution in the amount of latex produced."

According to the above theory, the yield of latex should be most abundant when the trees are leafless, as they cannot then lose much water by transpiration; it is of interest to note that the experiments made by Arden in 1902 seem to give support to this view. Arden states that the yield from trees tapped when they were leafless was much greater than that from trees tapped when the leaves were beginning to appear or when in full foliage. In Nicaragua the latex from other rubber trees contains the highest percentage of caoutchouc during the dry season. The possession of abundance of latex during the dry season lends support to the theory of its function as a water store during drought.

In many parts of the tropics, however, the leafless period occurs when the dryness and temperature of the air are at the maximum, and the collecting of latex would, during such a time, be limited to the very early part of the day and evening. The results quoted elsewhere tend to show that the best flow of latex is obtained in Ceylon, when the air and soil are abundantly supplied with moisture and when the temperature is comparatively low. A period of drought lasting only seven or twelve days appreciably affects the flow of latex, but though, under such conditions, the quantity is reduced, the quality is usually improved. The latex rapidly dries on the tree in hot dry weather; this can, however, be overcome by the use of ammonia, formalin, &c., placed in the drip-tins at the top of each incision. In the Amazon valley the native collectors never tap the trees when in flower, as they believe the amount of rubber then obtainable is much less than at other times—an idea supported by Ridley's experiments at the Botanic Gardens, Singapore.

It is very unlikely that the collection of latex will be limited to the dry period, when the trees pass through their foliar phase, and in practice tapping during almost every month is much more likely to be adopted.

* H. N. Ridley, Agri. Bull, Straits and F. M. S., May, 1904.

RESULTS AT HENARATGODA.

Regarding this question the results given below may be of value. The trees marked "H" were first tapped when the leaf-fall commenced, and the operations were continued through the period of leaf-fall and renewal. The trees marked "I" were tapped from the first of October right through the rainy and dry seasons; on a few days tapping was not carried out owing to inclement weather. The experiment was made at Henaratgoda.

	Number of Times tapped.	Yield of Dry Rubber per 5 trees. lb. oz.
Trees tapped every day from October 1, 1905, (I) ..	157	38 12 $\frac{1}{2}$
Trees tapped every day: first tapped on February 1, 1906 (H)..	68	13 14 $\frac{1}{2}$

The tapping operations (I) were continued at Henaratgoda right through the dry months of January to April; towards the end of the latter month the flow of latex was not copious, and in some cases the coagulation, instead of being complete in 24 hours, required a period of nearly two days.

On estates possessing rubber only it is difficult to see how the labour can be kept employed if tapping is suspended during the dry months, and the point to determine is the maximum frequency that the trees can be tapped with the minimum damage to the tree during these months. The above phenomena were observed in trees (I) which had been regularly tapped from September, 1905, to April, 1906, during which period the trees shed all their leaves and produced new foliage and flowers.

WHAT PART OF THE DAY TO TAP.

The best flow of latex with the minimum quantity of scrap rubber is obtained in the early morning or evening on sunny days, but tapping may be done further on into the day, when the temperature is low and clouds and moisture are abundant. In a district like Peradeniya tapping may be continued up to 8 or 9 A.M., and re-commenced at 3 to 4 P.M. All-night tapping is of course only possible when the artificial lighting of estates is more perfect than at present.

In the early and late parts of the day the temperature is lower, the air usually more moist, and there is less transpiration of water from the leaves: the combined effect of these factors is a better flow of latex during such times. According to Ridley*

* Annual Report of the Director, Botanic Gardens, Singapore.



Photo by Ivor Etherington.

HEVEA BRASILIENSIS TAPPED EVERY DAY.

PARING & PRICKING METHOD.

9 LB. DRY RUBBER FROM 264 TAPPINGS.

the girth of the tree decreases during the day and increases towards evening, an observation which may throw some light on the theories regarding tension of the laticiferous tissue and transpiration.

Ridley also states (Annual Report of the Botanic Gardens, Singapore and Penang, for 1904) that the most favourable times for tapping are morning and evening, and from the same number of trees which produced a total amount of 578 lb., the morning trees realized 314 lb., while the evening trees gave only 263 lb., showing a difference in favour of the morning tapping of 51 lb. Ridley and Derry concluded that evening tappings to be successful should be deferred to as late an hour as possible.

COMPASS TAPPING.

Several experiments have been carried out with the object of proving which is the best part of the tree to tap during morning and evening. It would appear that the tapping areas of the trees can be conveniently divided into four parts: one side to face north, the next south, and the other two east and west respectively. Each side can be tapped on a definite system, say once per day, twice per week, and so on. When the east side has to be tapped it is best to perform the operation in the afternoon or evening, and to tap the west side during the early part of the day; such a method, applicable to the east and west sides of the tree, prevents direct exposure of the tapping area to the sun's rays during working operations, and allows the flow of latex to continue for a slightly longer period of time.

FREQUENCY OF TAPPING.

The frequency of tapping varies considerably, but it is by no means clearly proved that the tree will not stand tapping every alternate day throughout the greater part of the year. The fact that an interval of one day is sufficient for the wound response to become obvious is of interest and importance.

It is perhaps not advisable to judge the effect of very frequent tapping from the results obtained in the Amazon Districts, as there the trees are usually very old, and in many cases have never been tapped before. Nevertheless, it is of interest to learn that in those districts the Para rubber tree is often tapped for 180 days each year without apparently doing very serious damage to the trees.

In Ceylon tapping every day throughout alternate months, or every day when moisture is abundant, or on alternate days throughout the year, has given good yields.

The following results of experiments at Henaratgoda are of value as they show what yields have been obtained by tapping trees of similar age at varying intervals. The tapping operations

were commenced in September, 1905, and ended in February, 1906, the full spiral system being adopted in all the cases quoted below, from the base to a height of five to six feet.

These results suggest that the average amount of rubber, obtainable per tapping operation, is likely to increase when an interval of one or more days is allowed between successive operations. They also indicate that the average yield, per tapping, is better when the trees are incised every alternate day than when tapped once per day or once per week: at Singapore the yields obtained by tapping every day were better than those secured by tapping every alternate day. From a practical standpoint, however, the total quantity of rubber obtainable when the trees are judiciously tapped at regular intervals is of more importance than the deductions just made; the latter must not be construed as contradicting the accepted theory of wound response previously discussed.

Frequency of Tapping.	Number of Times tapped.	Number of Trees.	Yield of Dry Rubber per five trees		Yield of Rubber per tapping, per five trees.	
			lb.	oz.	lb.	oz.
Every day (D) ..	168	5	42	7½	..	4·0
Every alternate day (E) ..	83	5	49	7½	..	9·5
Twice per week (A) ..	57	25	14	0	..	4·0
Once per week (F) ..	28	5	12	9½	..	7·7
Once per month (G) ..	7	5	0	15½	..	2·1

The following table* shows the results obtained in Ceylon by tapping trees at different periods during eleven months:—

Frequency of tapping.	Number of times tapped.	Number of trees.	Yield of dry rubber per tree.	
			lb.	oz.
Every day ..	270	5	11	0
Every alternate day ...	136	5	12	8
Twice per week ...	91	25	2	8
Once per week ...	44	5	3	13
Once per month ...	11	5	0	19

FREQUENCY OF TAPPING AT SINGAPORE.

Ridley's experiments (Ag. Bull., December, 1906) have been carefully carried out on the trees in the Botanic Garden at Singapore, and the following results were obtained up to December 1906:—

On 50 trees, averaging in girth 3 ft. 7 in. the tappings included one evening period, and it was noticed that the ratio of caoutchouc

* Science of Para Rubber Cultivation: A. M. & J. Ferguson, Colombo, 1907.



Photo by Ivor Etherington.

HEVEA BRASILIENSIS TAPPED EVERY ALTERNATE DAY.

PARING & PRICKING METHOD.

11 LB DRY RUBBER FROM 181 TAPPINGS

to latex for the second period or evening tappings was better than the first or morning tappings, although the interval of rest was only $2\frac{1}{2}$ months or slightly less.

In the second experiments carried out on 120 trees averaging about 3 ft. in girth, the interval of rest between the two periods of tappings was under $1\frac{1}{2}$ months, the second comparing unfavourably with the first period, and the evening poorer than the morning.

In the third experiment 140 trees, with an average girth of 2 ft. $5\frac{1}{2}$ in. exactly an interval of two months' rest was allowed; the result emphasized the necessity of a longer period and the advantage of morning over evening tapping.

In the fourth experiment carried out on 207 trees averaging 3 ft. $2\frac{3}{4}$ in. in girth the variations of different groups were strikingly illustrated.

The fifth was an experiment confirming the necessity of an interval of rest of six months, and the advantage of morning over evening tappings. The trees were 200 in number and averaged 3 ft. $1\frac{1}{4}$ in. in girth.

The sixth experiment shows that daily tappings gave, at Singapore, a better result than tapping on alternate days.

TAPPING SEASONS.

The results for a period of one year with the garden trees were as follows:—

No. of Experiment.	Groups of Trees.	Average girth per Tree.		Period of Tapping.		Ratio of Fluid oz. to 1 oz. Dry rubber Avoirdupois.	No. of times tapped within one year.	Remarks.
				1905.	1906.			
I.	50	Ft.	In.	Aug-Sept.		5 14-16th	1st Period	Mornings
"	"	3	7	Nov-Dec.		5 3-16th	2nd "	Evenings
II.	120	3	$0\frac{3}{8}$	Sept-Oct.	June-July.	4 $1\frac{1}{2}$ -16th	3rd "	Mornings
						4 $\frac{1}{8}$	1st "	Mornings
						7 $\frac{1}{2}$	2nd "	Evenings
III.	140	2	$5\frac{1}{4}$	Dec. Sept-Oct.		4 $\frac{1}{4}$	1st "	Mornings
				Dec.	Jan.	9	2nd "	Evenings
IV.	200	3	$2\frac{3}{4}$	Oct-Nov.	Mar-April.	3 11-16th	1st "	Mornings
						4 7-16th	2nd "	Mornings
V.	200	3	$1\frac{1}{4}$	Oct-Nov.	May.	5 1-16th	1st "	Evenings
						4 $5\frac{1}{2}$ -16th	2nd "	Mornings
VI.	150	4	$5\frac{7}{8}$	Nov-Dec.		5 3-16th	1st "	Mornings
"	"	"	"	Jan.	June-July.	3 9-16th	2nd "	Mornings

Ridley concludes that "mornings are better than evenings tappings, that trees can be tapped twice within the period of a

year, but the interval of rest should not be less than five months, that the dormant months December, January and February yield a smaller percentage of caoutchouc, and that the best season for tapping is from April to November."

On the property of the Vallambrosa Rubber Co., Ltd., the excision system of tapping is employed and the half-herring-bone plan adopted. The trees are tapped at intervals of four months for 14 to 16 alternate days at a stretch and good yields obtained.

On Lanadron Estate, F.M.S., the young trees when tapped on the basal V. system can be operated upon regularly about every other day throughout the year.



BASAL TAPPING
THE Y SYSTEM.



Photo by Chas. Northway.

BASAL SPIRAL LINES.

CHAPTER X.

YIELDS OF PARA RUBBER.

Natural variations—Yields in Brazil and Ceylon—Henaratgoda trees and Amazon yields—Yields on estates in Ceylon: Matale, Uva, Kalutara, and Ambalangoda Districts—Illustration showing the rubber trees on Passara Group Estate— $\frac{3}{4}$ to 5 lb. averages over large acreages—Yields obtained in the Kalutara District for 1905 by the Kalutara Rubber Co., Rayigam Tea Co., Neboda Tea Co., Vogan Tea Co., Southern Ceylon Tea and Rubber Co., Putupaula Tea Estate Co., Yatiyantota Ceylon Tea Co., Eastern Produce and Estates Co., Sunnigama Ceylon Estates Co., Yataderiya Tea Co., Kepitigalla and Passara Group Estates, Ceylon Tea and Coconut Estate Co., Ambalangoda Estate, Balgownie Rubber Co., Pataling Rubber Co., and Gikiyanakanda—Yields on Imboolpitiya estate, Nawalapitiya—Illustration showing rubber trees at Peradeniya tapped on the full spiral system—Exceptional yields at Culloden, Elpitiya, and Peradeniya—Comparison of yields at Peradeniya and Henaratgoda—Experiments at Henaratgoda—Comparative yields from different systems of tapping—Spiral and herring-bone tapping compared—Yields obtained at Henaratgoda in 11 months—Results of high tapping at Henaratgoda from base to 50 feet—High yield from basal tapping only—16 tappings yield $3\frac{1}{2}$ lb. rubber—Average yielding capacity per square foot of the bark tissues—Comparison of yields obtained at Henaratgoda—Illustration showing the Elpitiya tree after 14 lb. rubber extracted—Yields at Peradeniya by the V and spiral methods—Rubber from shavings—Rubber Yields in Malaya—Yield from young trees on Lanadron Estate—Yield from old trees at Singapore—Yield during 1906 in Federated Malay States, Straits Settlements and Johore—Yield during 1906 in Selangor, Perak, Negri Sembilan and Pahang—Yield from the Sandycroft Rubber Co., 1905—Variation in yields in Java—Yields in South India at high elevations—Hawthorn Estate and Mergui Rubber Plantations—Para yields in the Gold Coast—Yields of Para and African Rubber compared—Yield per tree during 1906 and 1907 on the properties of the Consolidated Malay; Anglo American Direct Tea Trading; Anglo Malay; Black-water; The Kalutara Co.; Kepitigalla; Pelmadulla; Yatiyantota; Shelford; Sandycroft; Ledbury; Yataderiya; Perak; Bukit Rajah; Vallambrosa; Highlands and Lowlands; Cicely; Pataling; Asiatics; Consolidated Malay; Eastern Produce; Golden Hope; Shelford; Union Estates; Bertram; Balgownie; Kuala Lumpur; Rubber Plantations; Kalumpang Estate—Yield per acre on Kuala Selangor Co.; Malay States Coffee Co.; Rubber Growers Co.; Selangor Rubber Co.; Seremban Estate Rubber Co.—Total yields from estates in the East from 1905 to 1908—Official returns for Federated Malay States 1907—Yield and distance apart of trees—Yields on various fields of the Vallambrosa Rubber Co.—Yields on fields of the Highlands and Lowlands Estate—Yields from trees of known girth at Singapore—Cost of Rubber production on properties of Asiatic Rubber and Produce Co.; Highlands and Lowlands Co.; Pataling Rubber Estates; Vallambrosa; Vogan; Yatiyantota; Seremban Estate; Balgownie; Kuala Lumpur—Annual increase in output from estates: Gikiyanakanda from 1903 to 1908—Difficulty in forming average estimates of yield

NATURAL VARIATIONS.

WHEN dealing with the question of yields of dry rubber for a known acreage or number of trees, it is necessary to indicate the method of tapping adopted, the age of the trees, and the quality

of the resultant rubber. The age and size of trees greatly influence the quantity and quality of the rubber, and it is to be regretted that the yields over large acreages for several years in succession are not at hand. Nevertheless, we do possess information of the yield of particular trees during certain years and of large acreages of known age for a limited period, and from these a fairly reliable statement of probable yields can be arrived at. It should be clearly understood that the yield from trees of the same age may be doubled, trebled, or quadrupled within a year by a change in the method of tapping, and that those methods usually give the largest yields which tap the latex tubes over the largest area.

It should also be remembered that individual trees, either from internal or external causes, show considerable variation in the quantity and quality of latex they give, though of the same age and tapped in a similar manner. At Henaratgoda, where the trees range in age from 15 to 30 years, and where tapping has been done on various sections of the trees from the base to 6, 16, 20, 30, and 50 feet, the opportunities to observe the variation in yield of latex and rubber have been numerous. The first six feet from the base, though tapped over the same area, in the same manner, and with the same implements, have given a yield varying from six twenty-fifths of an ounce to nearly two ounces of rubber per tapping per tree; other parts of the stems of individual trees have varied in their daily yield of rubber from three-fifths of an ounce to five and one-fifth ounces, one-quarter to one and one-twentieth ounces, nine-fortieths to thirty-three fortieths of an ounce, &c., and in one case, where the tree has been regularly tapped from the base to a height of 50 feet, the yield of dry rubber has sometimes been as high as eight and three-quarter ounces per tree per tapping, and on other occasions as low as a quarter of an ounce. Such variations can, in most cases, be mainly attributed to internal conditions rather than external climatic forces. Results of tapping operations are available from different countries, and it will be best to commence with those obtained in Brazil.

YIELDS IN BRAZIL.

In Brazil, from a group of 120 to 180 trees, each man is expected to collect about 8 to 10 litres of latex, and though this is regarded as a fair average, as much as 40 litres (10 gallons) have been collected from such a group in one day. Bonnechaux* asserts that the average yield of rubber per tree, per day, is from 26 to 33 grammes, and that a group of 150 trees will yield during the tapping season in each year 400 to 500 kilos of caoutchouc.

Seeligmann† states that in the Amazon valley as much as 30 c.c. of milk are obtainable from single oblique incisions, the latex

* See Junelle *Lc.*

† Seeligmann, *Caoutchouc et la Gutta Percha* p. 48



Photo by Colombo Apothecaries Co.

PARA RUBBER IN CEYLON.

RUBBER AND CACAO IN BEARING, MATALE.

DANGAN ESTATE, RUBBER PLANTATIONS, LTD.

flowing from one to three hours. Parkin was of the opinion that the Amazon yields were far in excess of those obtainable in Ceylon, and gave a modest average of 2 to 3 c.c., which might be worked up to 10 to 12 c.c. of latex as a yield to be expected from single oblique cuts in Ceylon.

RUBBER YIELDS IN CEYLON.

The yield of rubber varies from 7 lb. per 400 trees in one tapping to a maximum of 25 lb. per tree in twelve months' tapping.

The first series of reliable yields* were those obtained at Henaratgoda from 1888 to 1896. One tree at Henaratgoda was lightly tapped every second year, and gave for nine years an average annual yield of $1\frac{1}{2}$ lb. of dry rubber:—

27 $\frac{3}{4}$ oz. in 1888	51 oz. in 1894
42 oz. in 1890	48 $\frac{1}{4}$ oz. in 1896
5 oz. in 1892	

This tree was twelve years old when first tapped, and the annual yield of $1\frac{1}{2}$ lb. was from the 12th to the 20th year of the tree's life. The method of tapping consisted of scraping off the rough outer bark and making numerous V-shaped incisions to a height of about five feet. The tree had a circumference of $50\frac{1}{2}$ inches and was growing with other trees of nearly equal size, distanced 30 feet apart.

Other experiments have been made at Henaratgoda which indicated similar results by consecutive weekly tapplings of the trees.

YIELDS ON ESTATES IN CEYLON.

To form an estimate of the yield to be obtained from large acreages of Para rubber trees of known age is no easy task, and the best way to deal with this part of the subject is to give only the results which have been obtained on rubber estates in the island

Matale District.

In the Matale District there are estates where an average yield of $\frac{3}{4}$ lb. of dry rubber per tree from 5,000 trees has been secured in one month's tapping. The average circumference of these trees was 35 inches a yard from the ground.

On another property a yield of $3\frac{1}{2}$ lb. of rubber per tree has been obtained from 499 trees in seven months' tapping. Another estate, in the same district, has obtained an average yield of $3\frac{1}{2}$ lb. of dry rubber per tree from 311 trees in one year. The age of these trees varied from 10 to 15 years, and the trees varied in circumference from 30 to 70 inches at a yard from the ground. They were tapped on the full herring-bone system; the tapping area covered half the tree and extended from the base to a height of seven feet.

* Dr. Trimen, Notes on Rubber Experiments.

The tapping was done very carefully, a distance of seven feet being worked through in 240 days of continuous tapping. The yield from these particular trees will probably be increased by a change in the method of tapping and tapping instruments.

On a third Matale estate the Para rubber is planted among cacao; the cacao is planted 12 by 12 feet and the rubber through alternate lines of cacao 24 by 12 feet. By the V method of tapping a yield of 3 lb. of dry rubber from each of 10,000 trees is expected the trees being 8 to 15 years old. On this estate several encouraging experiments in tapping from 6 feet upwards to a height of 15 feet have been made, light ladders being used for the purpose.

The Province of Uva.

The most successful results at high elevations in Ceylon have probably been obtained in the Province of Uva. On Passara Group estate, Passara, Para rubber is being cultivated up to and over 3,000 feet above sea-level. The trees are of various ages, and one specimen 13 years old measured 54 inches in circumference a yard from the ground, and 60 to 70 feet in height, though growing at an elevation of about 2,600 feet. Tapping has been carried on with promising results up to 2,800 feet; from the trees at an elevation of 2,600 feet, varying in age from 7 to 13 years, an average yield of 2 lb. of dry rubber per tree was obtained during 1905. These results are of considerable interest and importance, and I have to thank Mr. W. Stewart Taylor for the information he has given me. An illustration showing the rubber trees at 2,600 feet above sea-level is here reproduced.

A considerable amount of Para rubber is likely to be planted in the Badulla, Passara, Monaragala, and Bibile Districts, and in many cases the altitude is considerably over 2,000 feet.

South Ceylon: Kalutara, Ambalangoda, Rayigam, &c.

In the South of Ceylon equally good and often better results have been obtained. On one estate 8,731 trees, having a minimum circumference of twenty inches, gave in one year an average of 1.72 lb. of dry rubber per tree. On the same property an average of 2 lb. per tree from each of about 10,000 trees was expected during 1906. There are on this estate four old trees which have given 10 to 25 lb. of dry rubber per tree in twelve months; the trees are perfectly healthy, and give a good crop of sound seed every year. Further tapping has been done on these trees with excellent results.

A section of another rubber property in the South of Ceylon gave, from 11-year-old trees, the average circumference of which was 30 inches only, no less than 5½ lb. of dry rubber from each of 255 trees. The eight largest trees on this property yielded no less



Photo lent by the Kegalle Planters' Association.
TAPPING MATURE TREES. YATADERIYA ESTATE, KEGALLE.

than 16 lb. of dry rubber each in twelve months; the newly-formed cortex has been tapped again, and a good flow of latex secured. These results have been obtained by the half or full spiral system of tapping.

The quantity of rubber harvested during 1905 in the Kalutara District was 101,978 lb. from 88,667 trees, which shows an average of about 1.15 lb. per tree. A large number of these trees, about 43 per cent., were tapped for the first time, but as nearly all the older trees in the district are planted in selected spots and at great distances, the Kalutara Association do not expect to see any increase in the yield per tree for a considerable number of years. As yet there are insufficient trees in bearing in rubber alone to enable the Kalutara planters to estimate with any degree of certainty what the yield per acre is likely to be.

During the year 1905 the Kalutara Rubber Company, Limited, tapped 1,135 trees, and obtained a yield of $1\frac{1}{4}$ lb. of rubber per tree. The Ceylon Tea & Coconut Estates Co., Ltd., tapped in 1905, 1,751 trees, and obtained 958 lb. of rubber.

The rubber trees on the property of the Rayigam Tea Co., Ltd., were tapped in 1905, 2,220 lb. of rubber being obtained from about 1,800 trees.

The Neboda Tea Co. of Ceylon, Ltd., in their annual report for 1905, state that 370 trees reached the tapping stage during the year, and gave 820 lb. of dry rubber or an average yield of $2\frac{1}{3}$ lb. per tree per annum.

The Vogan Tea Co. of Ceylon obtained in 1905 a crop of 3,056 lb. of rubber from 2,800 trees; the cost of harvesting, including all expenditure on tapping knives, cups, &c., being Re. 1.05 per lb. of rubber.

The Yataderiya Tea Co. secured, in 1905, 2,855 lb. of rubber from 5,324 trees, the greater number of the trees being only lightly tapped towards the close of the season.

The Southern Ceylon Tea & Rubber Co., in their report for 1905, state that in about 8 months' tapping, from 577 trees, 614 lb. of rubber have been obtained, most of the trees being in their seventh year.

The Putupaula Tea Estate Co., Ltd., in their annual report for 1905, state that 4,982 lb. of rubber were harvested, the crop being equal to $1\frac{3}{4}$ lb. of rubber per tree.

The Yatiyantota Ceylon Tea Co., Ltd., report that during 1905 the crop of rubber amounted to 8,212 lb. from about 4,636 trees, or an average of $1\frac{7}{16}$ lb. per tree.

The Eastern Produce & Estates Co., Ltd., report for 1905 that 12,515 lb. of rubber were obtained, and that 12,000 trees would be available for tapping in 1906.

During 1905 one hundred Para rubber trees on the property of the Sunnigama Ceylon Estates Co., Ltd., gave $3\frac{1}{4}$ lb. of dry rubber each.

YIELDS ON GIKIYANAKANDA FOR 1905.

The results obtained on the above estate for 1905 are of importance as showing reliable details of yield and dimensions of trees. During the year, 5,598 trees were tapped; of these, 2,207 had been previously tapped. Between January and March 1,346 new trees were operated on for the first time, and again between July and October other 2,045 trees were tapped for the first time. The minimum girth of the trees, which were tapped for the first time, was 20 inches at a yard from the ground, and the census at the end of the year showed that 3,811 out of the 5,598 had a circumference of 24 inches or over. The trees were tapped on the full herring-bone system, each tree being tapped every alternate day. The paring operations were done carefully, the width of excised bark being slightly less than one inch per month. The total quantity of rubber from the 5,598 trees, some of which were tapped from January onwards, others only from October, was 7,592 lb. or 1.34 lb. per tree. It is interesting to know that the total cost per lb. for collecting, including knives, tins, &c., was 53.46 cents and for curing 6.25 cents per pound of rubber. I have to thank Mr. G. H. Gollidge for his kindness in favouring me with the results of his work during 1905.

YIELDS ON IMBOOLPITIYA ESTATE, NAWALAPITIYA, CEYLON.

An interesting series of yields, for which I am indebted to Mr. Albert Rosling, has been obtained on the above estate, situated in the Ambagamuwa District, at an elevation of 2,000 feet, where the rainfall average for 20 years is $144\frac{1}{2}$ inches per year.

The tapping operations were commenced on 18th December, 1905, and terminated on 18th March, 1906, so that the collection of the latex was carried out during three very dry months and through the period when the trees changed their foliage. The following are the yields obtained, inclusive of scrap:—

Age of Trees.	Number of Times tapped.	Weight of Dry Rubber obtained in 3 months.
One tree 28 years old	17	3 lb. 7 oz.
Two trees „ „ „	21	11 „ 7
Thirty-six young trees	19	{ 4 3
Ten „ „	6	

The two trees, 28 years old, gave during September and October, 1905, 12,000 seeds; the other tree of the same age seldom yields more than 400 to 500 seeds annually.

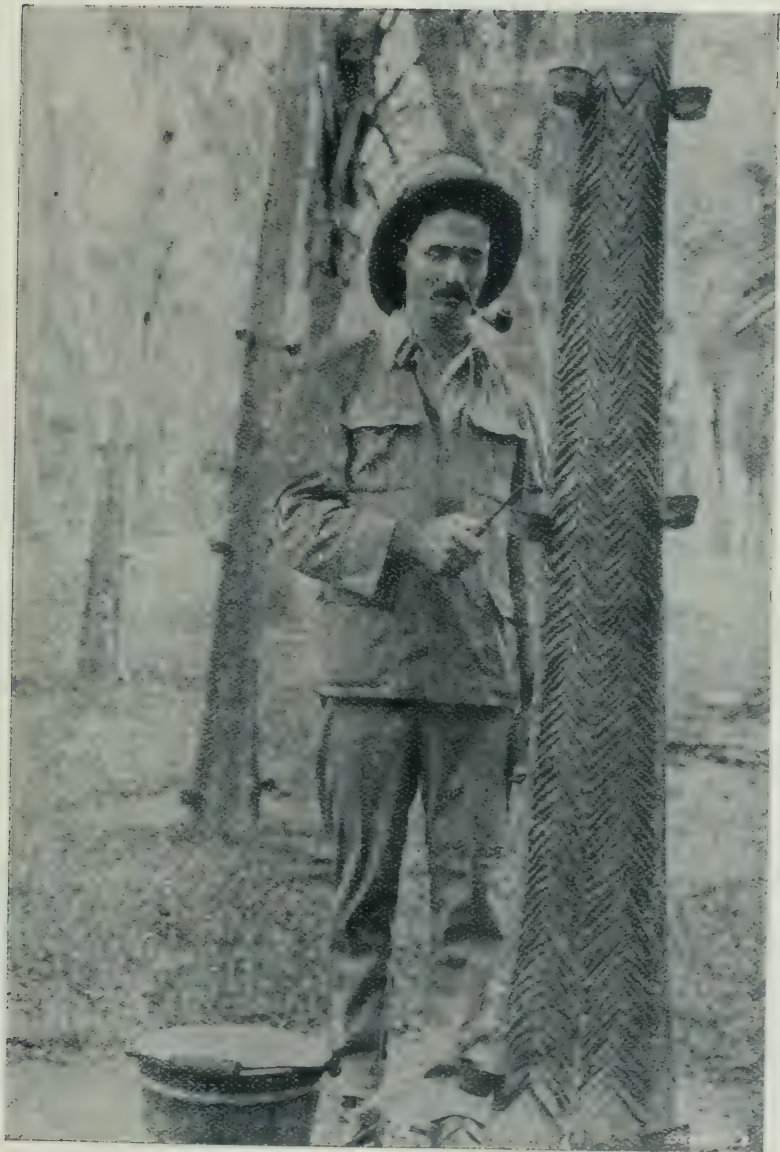


Photo lent by A. W. W. Gray.

PARA RUBBER IN CEYLON.
KURUNEGALA DISTRICT.

TAPPING MATURE TREES IN 1905. ARAMPOLA ESTATE, KURUNEGALA, CEYLON.

COMPARISON OF YIELDS FROM CEYLON PROPERTIES IN 1905.

Having indicated the yields obtained in various parts of the world and those from estates and exceptional trees in Ceylon, the following synopsis is given to assist those who desire to form an estimate of probable future yields:—

Name of Rubber Property.	Yield of Rubber obtained in 1905.	Number of Trees tapped.	Average Yield per tree per year.	Particulars of trees tapped.
Neboda Tea Co. of Ceylon, Ltd., Ceylon.	lb. 820	370	lb. 2½	Young, and attained tapping stage in 1905.
Passara Group estate in Uva, Ceylon: elevation 2,600 ft.	740	370	2	Trees 6 to 13 years old
Kalutara Estate, Ceylon.	15,017	8,731	1.72	Minimum circumference of trees was 20 inches.
Kalutara Rubber Co., Ltd., Ceylon.	1,419	1,135	1½	
Kalutara District in Ceylon.	101,978	88,667	1.15	43 per cent. were tapped for the first time.
Vogan Tea Co. of Ceylon.	3,056	2,800	1.09	
Rayigam Tea Co. of Ceylon.	2,220	1,800	1.2	
Putupaula Tea Estate Co.	4,982	—	1½	
Yatiantota Ceylon Tea Co.	8,212	4,636	1.7	
Sunnygama Ceylon Estates Co.	325	100	3¼	
Yataderiya Tea Co., Ceylon.	2,855	5,224	0.5	Varied in circumference from 18 to 61 inches.
Kepitigalla, Matale, Ceylon.	30,000	10,000	3	Trees from 8 to 15 years old.

[Continued over.]

PARA RUBBER.

Name of Rubber Property.	Yield of Rubber obtained in 1905.	Number of Trees tapped.	Average Yield per tree per year.	Particulars of Trees tapped.
Henaratgoda Gardens, Ceylon.	lb. 132 $\frac{5}{16}$ in 4 $\frac{1}{2}$ months	75	lb. 1·7 in 4 $\frac{1}{2}$ months	The circumference of the tapped trees ranges from 33 to 69 in
Gikiyanakanda, Nerboda, Ceylon.	7,529	5,598	1·34	Some tapped for first time others previously tapped.
The Ceylon Tea and Coconut Estates Co., Ltd.	953	1,751	0·5	Mainly young trees.
Rubber Estate, Matale, Ceylon.	1,088	311	3 $\frac{1}{2}$	Girth of trees varies from 30 to 70 in.
Rubber Estate, Matale, Ceylon.	1,596	499	3 $\frac{1}{5}$	11-year-old trees in seven months' tapplings.
Rubber estate, Matale, Ceylon.	3,750	5,000	3 $\frac{3}{4}$	Average girth of trees is 35 inches.
Rubber estate, Ambalangoda, Ceylon.	1,400	255	5 $\frac{1}{2}$	Average girth is 30 inches.
Rubber estate, Ambalangoda, Ceylon, 1904	208	501	0·41	Tapped on V system.
Do. 1905	908	617	1·47	Some trees tapped spirally.
Balgownio	1,040	3,200	0·32	
Pataling	25,700	25,000	0·9	

The trees on the various rubber properties enumerated above differ widely in age, size, &c., and are growing in dissimilar climates. The results are, however, of value in so far that they show the yields obtained in an early stage of the industry, when our knowledge was necessarily meagre and our methods open to considerable improvement.

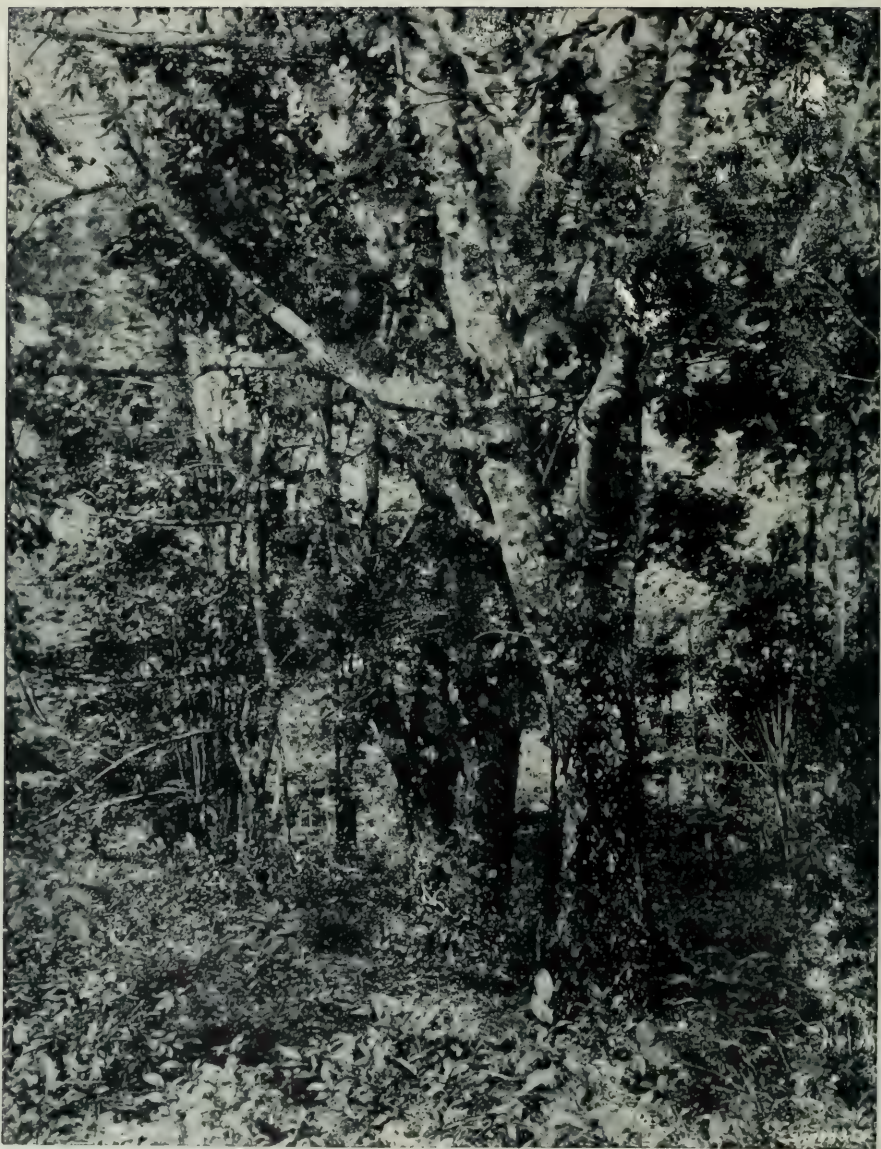


Photo by C. H. Kerr.

PARA RUBBER IN CEYLON.

KALUTARA DISTRICT.

THE FAMOUS TREES, SOME OF WHICH HAVE GIVEN 25 LB. RUBBER IN ONE YEAR.

CULLODEN ESTATE, KALUTARA, CEYLON.

EXCEPTIONAL YIELDS.

These results have, however, been completely surpassed by those obtained on exceptional trees during the last few years. Trees of unknown age in Ceylon (probably 20 to 25 years) have given 10, 18, 23, and 25 lb. of rubber in twelve months' time; other trees, only eleven years old, have in eight months' tapping given 14 lb. of dry rubber each, and others from 2 to 4 lb. in two to three months. Light tapping of young trees has given 1.72 lb. of rubber per tree on a well-known Kalutara property. These results are so significant that space for tabulating them is here given, although it must be clearly understood that they are exceptional:—

District.	Age of Trees.	Tapping period.	Yield.	Tapping method.
Culloden	.. 20 to 25 years	12 months	(a) 10 lb. (b) 18 „ (c) 23 „ (d) 25 „	} Various
Elpitiya	.. 11 „	12 „	16 „	
Peradeniya	.. 20 „	12 weeks 8 months	about 3 „ 6½ „	
Kepitigalla	.. 8 to 15 „ 11 „	12 months 12 „	2 „ 3 „	V cuts V cuts

The ten old trees on Culloden were again tapped on the herring-bone system from 1st November to the 8th December, 1905, and gave an average of over 12 lb. of dry rubber per tree. A photograph is, by permission of the Agents and Messrs. Capper & Sons, Colombo, given elsewhere showing the trees from which these large yields have been obtained. I saw these trees in April, 1908, and was informed that they had given an average yield of 18 lb. per annum for four years.

The Elpitiya tree had a circumference of 46 inches; the tapping was commenced in October, 1904; the tree was rested in November, tapped again in December, rested in January, 1905, and continuously tapped from February to June, 1905. Tapping was re-commenced in September, 1905. This tree appeared quite healthy in April, 1908.

YIELD FROM PERADENIYA TREES.

The following are the details of the trees at Peradeniya, which were tapped either on the spiral or V system. The letter P indicates the days on which the spur knife was used.

It will be noticed that the quantity of latex obtained by the use of Bowman's and Northway's spur knife was usually much greater than that obtained by the paring knife; this was to some extent due

to the fact that the innermost laticiferous tubes near the cambium were penetrated by the points of the spur.

It is, however, an open question whether the total yield from a series of pricking and paring operations is in excess of that obtained by the same number of parings, if a long enough interval of time is allowed to elapse. The large yield resulting from the use of the spur knife was followed by a poor flow after paring.

The illustrations on the accompanying plates show the Peradeniya trees referred to in the following records of yields :—

FOUR PERADENIYA TREES—29 YEARS OLD :

YIELD OF RUBBER FROM V CUTS.

Date.	Weight. lb. oz.	Date.	Weight. lb. oz.
29-6-05 ..	4	Brought forward	9 12 ⁵ / ₈
1-7-05 ..	3 ³ / ₄	19-8-05 ..	2 ¹ / ₈
5-7-05 ..	11 ⁵ / ₈	P 21-8-05 ..	2 ¹ / ₈
7-7-05 ..	10 ¹ / ₄	22-8-05 ..	0 ⁵ / ₈
10-7-05 ..	14	P 23-8-05 ..	1 ⁵ / ₈
12-7-05 ..	12 ¹ / ₂	24-8-05 ..	0 ⁵ / ₈
14-7-05 ..	6 ¹ / ₄	P 25-8-05 ..	1 ³ / ₈
17-7-05 ..	9 ⁷ / ₈	26-8-05 ..	1 ³ / ₈
19-7-05 ..	8 ¹ / ₈	P 28-8-05 ..	1
21-7-05 ..	9 ¹ / ₄	29-8-05 ..	0 ⁴ / ₈
24-7-05 ..	7 ¹ / ₈	P 30-8-05 ..	1 ³ / ₈
26-7-05 ..	7	P 31-8-05 ..	1
28-7-05 ..	7	1-9-05 ..	0 ¹ / ₂
31-7-05 ..	7 ⁷ / ₈	P 2-9-05 ..	1 ¹ / ₄
2-8-05 ..	7	4-9-05 ..	0 ³ / ₈
3-8-05 ..	5 ⁵ / ₈	P 5-9-05 ..	1 ¹ / ₈
4-8-05 ..	3 ¹ / ₂	6-9-05 ..	0 ⁷ / ₈
5-8-05 ..	3 ¹ / ₄	P 7-9-05 ..	1 ¹ / ₈
7-8-05 ..	4 ⁷ / ₈	8-9-05 ..	0 ³ / ₈
9-8-05 ..	2 ⁷ / ₈	P 9-9-05 ..	1 ¹ / ₈
10-8-05 ..	1 ⁶ / ₈	11-9-05 ..	0 ¹ / ₂
11-8-05 ..	1 ⁶ / ₈	P 12-9-05 ..	1
12-8-05 ..	1 ⁵ / ₈	P 13-9-05 ..	0 ³ / ₄
P 15-8-05 ..	3	15-9-05 ..	0 ³ / ₈
17-8-05 ..	1 ³ / ₈	P 18-9-05 ..	1 ³ / ₈
P 18-8-05 ..	1 ⁵ / ₈		
Carried forward ..	9 12 ⁵ / ₈		11 5 ⁵ / ₈

The figure on the accompanying Plate shows the condition of one of the trees at the end of the tapping operations; the lines of adjacent V's were beginning to interfere with one another, and the trees were therefore rested. The average yield in the first five weeks was two pounds of rubber per tree, but subsequently the yield fell off considerably.

PARA RUBBER.

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RUBBER YIELD FROM LONG SPIRAL LINES.

FOUR PERAD NIYA TREES—29 YEARS OLD.

Date	Weight lb. oz.	Date	Weight lb. oz.
16-6-05	.. 3½	Brought forward	7 8½
17-6-05	.. 6	12-8-05	.. 2
19-6-05	.. 7½	P 14-8-05	.. 2
20-6-05	.. 13	16-8-05	.. 1½
21-6-05	.. 6½	P 17-8-05	.. 3
22-6-05	.. 6½	18-8-05	.. 2½
23-6-05	.. 5½	P 19-8-05	.. 2
24-6-05	.. 5	21-8-05	.. 1
26-6-05	.. 6½	P 22-8-05	.. 3
27-6-05	.. 3½	23-8-05	.. 1½
28-6-05	.. 7½	P 24-8-05	.. 1
30-6-05	.. 6½	25-8-05	.. 3
1-7-05	.. 6½	P 26-8-05	.. 1
3-7-05	.. 8½	28-8-05	.. 1
4-7-05	.. 7½	P 29-8-05	.. 3
6-7-05	.. 10½	30-8-05	.. 1
8-7-05	.. 9½	P 31-8-05	.. 3
11-7-05	.. 12½	P 1-9-05	.. 2
13-7-05	.. 10½	2-9-05	.. 1
14-7-05	.. 6½	P 4-9-05	.. 4
15-7-05	.. 7	5-9-05	.. 1½
18-7-05	.. 6½	P 6-9-05	.. 7
20-7-05	.. 5	7-9-05	.. 2
22-7-05	.. 4½	P 8-9-05	.. 3
23-7-05	.. 3½	P 9-9-05	.. 2½
27-7-05	.. 4½	11-9-05	.. 1½
29-7-05	.. 5	P 12-9-05	.. 1
1-8-05	.. 4½	P 13-9-05	.. 1½
3-8-05	.. 4	14-9-05	.. 1½
4-8-05	.. 3½	P 15-9-05	.. 1
5-8-05	.. 3½	P 18-9-05	.. 1
8-8-05	.. 4½		
9-8-05	.. 1½		
10-8-05	.. 2½		
11-8-05	.. 2½		
Carried forward	7 0½		
		From 28-10-05 to 16-2-06	
		= 9 lb. 10½ oz.	
		Total	.. 27 lb. 5 oz.

COMPARISON OF YIELDS AT PERADENIYA AND HENARATGODA.

The results which have been obtained from the full spiral system at Peradeniya are not as satisfactory as those at Henaratgoda, and are only briefly indicated here. At Peradeniya four trees, then nearly 30 years old, were tapped from June, 1905, to February, 1906, at irregular intervals. About three-quarters of the bark tissues were removed from the base to a height of five to six feet by alternately pricking and paring the lower surface. Altogether each tree

was tapped on 150 occasions during the time specified, and the yield obtained was approximately $6\frac{3}{4}$ lb. of dry rubber per tree.

At Henaratgoda 25 trees, from 15 to 20 years old, were tapped approximately twice per week from September 26th, 1905, to February, 1906. The pricker was used alternately with the paring knife, and in an interval of $4\frac{1}{2}$ months the width of bark tissues removed along each line was only $1\frac{1}{2}$ to 2 inches. The results show that by tapping on 37 occasions a total of $50\frac{1}{8}$ lb. of dry rubber can be obtained from 25 such trees.

The following shows some of the yields obtained by tapping on the long spiral system at Henaratgoda; each tree was tapped from the base to a height of 5 or 6 feet during a period of about $4\frac{1}{2}$ months:—

LONG SPIRAL TAPPING EXPERIMENTS.				
Number of times tapped.		Number of Trees.		Yield of Rubber.
				lb. $\frac{1}{8}$
37	..	25	..	$50\frac{1}{8}$
112	..	5	..	$30\frac{1}{8}$
56	..	5	..	$26\frac{1}{8}$
18	..	5	..	$8\frac{1}{8}$
100	..	5	..	$27\frac{1}{8}$

EXPERIMENTS AT HENARATGODA.

The objects of the experiments at Henaratgoda are numerous and have been made public on several occasions. One of them is concerned with the yield of dry rubber obtainable by different systems of tapping, and is of particular interest to those persons having rubber trees in bearing. A plantation of 75 rubber trees, 15 to 20 years old, was selected for the experiments and 25 trees in each of three groups were marked out and tapped on the (a) full spiral, (b) half-spiral, and (c) the full herring-bone systems. Tapping was commenced on the 26th September, 1905, and continued until the 13th of February, 1906, the latter being the period when most of the trees were undergoing their change of leaf.

It was impossible to obtain exact equality in all the physical conditions, and it is beyond the power of any one to calculate the individual potentialities of the selected trees; nevertheless, the following details will serve to indicate the results which may be obtained from such trees under conditions similar to those prevailing at the time of the experiments.



Photo by D. L. Gunawardane.

TAPPING THE RENEWED BARK AT ELPITIYA.

THE FIRST CORTICAL STRIPPING GAVE 16 LB. OF RUBBER IN 1 YEAR.

COMPARISON OF YIELDS BY DIFFERENT SYSTEMS OF TAPPING.

Base to 5 and 6 feet ; 25 Trees in each Group.

	Systems.					
	Full Spiral. (A)		Half-Spiral. (B)		Full herring- bone (C)	
Area excised, in square inches	12,414 $\frac{3}{4}$	..	5,003 $\frac{1}{2}$	..	7,348 $\frac{1}{2}$	
Number of times tapped	37	..	41	..	39	
Yield of dry rubber in lb.	50 $\frac{7}{8}$	..	35 $\frac{1}{2}$	..	47 $\frac{5}{8}$	
Yield of dry rubber per 5,000 square inches in lb.	20.49	..	34.47	..	32.55	
Yield of dry rubber per 40 tappings from 25 trees in lb.	55.0	..	34.20	..	48.52	

SPIRAL AND HERRING-BONE TAPPING COMPARED.

It is probably unwise to draw final conclusions from the above experiments, as the period occupied for the whole of the work lasted only about five months and the trees were 15 to 20 years old at the time of the experiment. But care was exercised to equalize, as far as possible, the physical conditions in the three sections and to avoid erroneous deductions being made. A synoptical statement of the significance of the above table is here given.

In the first case it is obvious that the full spiral system necessitates the stripping of the cortex or bark at the quickest rate, and the half-spiral at the minimum rate.

The *largest yield* per group of 25 trees was obtained from the *full spiral system*, the next best from the full herring-bone, and the *poorest yield* from the *half-spiral system* of tapping. This is only what may be expected when one realizes that the bark removed in the full spiral, full herring-bone, and half-spiral systems was in the ratio of 12 : 7 : 5, respectively. It seems reasonable to conclude that since the above results show that the maximum quantity of rubber per tree has been obtained from the full spiral system, such a system is to be recommended where it is expedient that the rubber should be placed on the market as quickly as possible irrespective of the effect on the trees. The adoption of this system removes the maximum quantity of bark, in a given time, and it is, therefore, the best one to adopt in thinning-out estates which are too closely planted.

On the other hand, it appears that the maximum quantity of rubber for equal areas of bark has been obtained from the half spiral system, and, therefore, that this system is not only the least harmful, but is the most economical, and is one which, on a permanent estate, will give the best yield from the available tapping area.

It should, however, be pointed out that in these experiments the different systems have been carried out in such a manner that the paring operations have only removed from $1\frac{1}{2}$ to $2\frac{1}{4}$ inches of cortex, along each incision, in five months. The tapping lines were originally 12 inches apart, so that the whole of the area prepared for tapping will only be worked through once in about two to three years. If the Para rubber tree is not too seriously injured by complete cortical stripping *once every three years*, it seems likely that the full spiral system of tapping, though the least economical, is one which might be adopted in the future on account of the large yields obtainable thereby.

YIELDS OBTAINED AT HENARATGODA.

The yields of rubber obtained from the oldest trees in Ceylon during a period of eleven months with alternate pricking and paring were as follows:—

No. of times tapped.	System of tapping.	Yield of dry rubber per tree.	
		lb.	oz.
91	L S	3	5
93	H S	2	8
92	F H	3	0
270	L S	11	0
136	L S	12	8
44	L S	3	13
11	L S	0	10
171	L S	7	7
257	L S	10	10
93	F H	14	8
95	F H	8	11
94	F H	12	3
94	F H	8	11
78	L S	10	14
84	F H	15	0

L. S. (Long spiral); H. S. (Half spiral); F. H. (Full herring bone.)

The highest yield of rubber was obtained from trees tapped from the base to fifty feet; these high tapping experiments were modified and worked on such a plan that the yield totaled about 14 lb. of dry rubber per tree in eleven months; there can be but little doubt that, if necessary, at the sacrifice of the tree, three times that amount could be obtained within one year. The cortical stripping necessary to give such a high yield within one year would, as was pointed out at the Ceylon Rubber Exhibition, in all probability kill the tree.

"RESULTS OF HIGH TAPPING AT HENARATGODA.

The foregoing results were obtained by tapping selected sides of trees from the base to five or six feet from the ground. In addition to these, other experiments were commenced in order to determine



Photo by D. L. Gunawardane.

HALF SPIRAL SYSTEM.

A TREE AFTER IT HAS GIVEN 14 LB. OF RUBBER.

the yield of dry rubber obtainable from different sections of the tree above the area usually tapped on estates.

RUBBER-YIELDING CAPACITY OF DIFFERENT AREAS.

<i>Base to 50 feet.</i>						
Base to 5 & 6 ft. lb.	6 to 16 feet. lb.	10 to 20 feet. lb.	20 to 30 feet. lb.	Base to 30 feet lb.	Base to 50 feet. lb.	
Yield of dry rubber per 5,000 square inches of excised bark.	32.55	29.03	22.28	16.45	13.13	5.96

The above results were obtained at Henaratgoda between September, 1905, and February, 1906, the system of tapping adopted being the full herring-bone. In most cases the quality of the rubber was good.

These experiments prove most definitely that the first six feet of bark produce larger proportions of rubber, per unit of excised bark, than any other, and that there is a general decrease in the rubber-yielding capacity of the bark the higher one goes up the stem. In the above results one can discern a fairly regular agreement, and as the figures for parts of the stem as high as fifty feet from the base have not been given before, the conclusions to be drawn are all the more interesting. Other results over larger surfaces agree, more or less, with the above, except that the average yield of rubber per square foot is often higher than that here given for the stem between 6 to 16 feet.

Basal tapping only, in the form of a Y, has, during 1907 and 1908, given very good yields in Ceylon and Malaya; in these operations only the first two feet from the base are tapped.

16 Tappings give 3½ lb. Rubber.

It is of considerable interest to note that though the rubber-yielding capacity of the cortex of the stem gradually decreases from below upwards, the yield of rubber obtainable from the higher parts of single trees, similar to those at Henaratgoda, is often surprisingly large. The following results show that as much as 3½ lb. of rubber may be obtained from *one* tree in 16 tapping operations.

Where tapped.	Number of times tapped.		Yield of Rubber per tree.
6 to 16 feet	..	16	2 lb. 5 ½ oz.
10 to 20 feet	..	16	3 lb 3 oz.
20 to 30 feet	..	16	2 lb. 6 oz.
Base to 30 feet	..	23	4 lb. 6 oz.
Base to 50 feet	..	8	1 lb. 10 oz

Other trees, tapped at similar levels, show very large but variable yields.

AVERAGE YIELDING CAPACITY OF THE CORTICAL TISSUES.

The yielding capacity of the Para rubber tree is influenced by its constitution and environmental conditions, and it may, at first, seem impossible to arrive at any reliable conclusions as to the rubber capacity per unit of cortical tissue. Dr. Tromp de Haas has determined the rubber-yielding value, under known conditions, per square metre of cortex for certain Para rubber trees in Java. A large number of results will be required before anything definite can be asserted, and the following figures should be useful for comparison with those of other observers. The experiments were carried out at Henaratgoda between September 26, 1905, and February 13, 1906, on trees 15 to 20 years old. The original groove, about one-quarter of an inch wide, was made without obtaining rubber in quantity; in subsequent operations the bark was removed by paring only when the yield of latex obtained by pricking the tubes was considered too small. The rubber was therefore obtained more by incising rather than excising the latex tubes.

Tapping Section.	Area excised, in square inches.	Yield of Rubber.	Yield of Rubber in ounces, per square foot of cortex removed.
		lb	
Base to 5 and 6 ft.	.. 7,348 $\frac{1}{4}$	.. 47 $\frac{5}{16}$	.. 14.8
6 to 16 feet	.. 796 $\frac{1}{2}$	.. 4 $\frac{3}{8}$	.. 13.37
10 to 20 feet	.. 1,472 $\frac{1}{2}$	.. 6 $\frac{9}{16}$	.. 10.26
20 to 30 feet	.. 1,424 $\frac{3}{4}$	.. 4 $\frac{11}{16}$	.. 7.58
Base to 30 feet	.. 1,666	.. 4 $\frac{3}{8}$	.. 6.05
Base to 50 feet	.. 2,726	.. 3 $\frac{1}{4}$	.. 2.74

The above results show what may, on an average, be expected by different systems of tapping—spiral and herring-bone—from parts of the tree from the base to a height of fifty feet. The trees, on account of their age, had moderately thick bark tissues, and the average yields per square foot are higher than those obtainable from younger trees. It is important to note that an average yield of over 13 ounces of rubber may be obtained per square foot of excised cortical tissue from the base up to 5 or 6 feet and from 6 to 16 feet from the base. It remains to be seen what proportion of rubber the remaining and renewed bark will give. In a fairly general way it may be stated that an increase in circumference of five inches gives an increase in the basal tapping area of 360 square inches, and from such an area an average of about $\frac{1}{2}$ lb. of dry rubber may be extracted from the bark of trees younger than those just dealt with.



PARA RUBBER IN CEYLON.

OLD PARA RUBBER AND TEA, NIKAKOTUA ESTATE, MATALE, CEYLON.

Photo by Ivor Ethvington.

COMPARISON OF YIELDS OBTAINED AT HENARATGODA.

The following synopsis is given to bring the results at Henaratgoda up to date; the yields from all the systems employed are included:—

Method of tapping.	Number of Trees tapped.	Area tapped.	Number of times tapped.	Total Yield of Rubber.
				lb. oz.
Full Spiral (A)	25	Base to 66"	57	71 4½
" (D)	5	Base to 60"	168	42 7½
" (E)	5	Base to 60"	83	49 7½
" (F)	5	" "	28	12 9½
" (G)	5	" "	7	0 15½
" (H)	5	" "	68	13 14½
" (I)	5	" 62"	157	38 12½
" (P)	1	" 30"	37	7 13½
Half-Spiral (B)	25	" 66"	60	46 13½
Full herring-bone (C)	25	" 66"	57	72 1½
" (M)	2	6 to 16'	45	10 15½
" (N)	2	10 to 20'	44	14 10½
" (O)	2	20 to 30'	44	9 12½
" (L)	1	Base to 30'	47	9 6½
" (W)	2	Base to 50'	37	13 13½

The above results were obtained from the 26th September, 1905, to April, 1906, from trees at Henaratgoda ranging in age from 15 to 20 years. In all cases but little of the available bark was excised. Further experiments were made on the same trees and satisfactory yields obtained (see page 120).

RUBBER FROM SHAVINGS.

According to Mr. G. H. Golledge it is estimated, in the Straits, that the shavings from 100 coolies' work will give about 25 lb. of dry rubber, but he is inclined to think that the parings to produce this must be rather thicker than those produced on carefully-worked estates in Ceylon. Mr. Golledge's figures are not final, but experience shows that he can obtain from 100 lb. of shavings some 7 to 8 lb. of dry rubber by the use of a rubber washing machine, consisting essentially of two rollers driven at different speeds under a stream of water. The actual quantity of rubber in the shavings is small; much more is attached to the strips of bark.

YIELDS IN MALAYA.

The results obtained by Ridley, Stanley Arden, Derry, and others have been published from time to time, and from them the following synopsis is made. The range in yield varies from 10 ounces per tree for 6-year-old trees to 9 lb. per tree for older specimens; in one case as much as 3 lb. of rubber has been reported from a well-grown three-year-old tree. Some trees, having a circumference of 36 inches, have given 3 lb. of dry rubber per tree; other trees, 24 inches or more in circumference, have been known to give only 2½ oz. of dry rubber each probably on account of their being too young. The yield

from young trees appears, however, to be more encouraging when the latest methods are adopted. Excellent results are said to have been obtained on Lanadron Estate, Johore, by cutting a large V at a foot to eighteen inches from the base of the tree, the V extending half round the tree; when the tree is large enough a second V is cut on the reverse side. By such a method the young trees can be tapped regularly—almost every alternate day—the rubber is extracted only from the thick part of the bark, and a high yield is obtained from the basal regions.

An old Para rubber tree at the Singapore Botanic Gardens was tapped in November and December, 1906, and 4 lb. 4½ oz. of dry rubber obtained; that made a total of 35 lb. 13½ oz. from the tree since it was first tapped. The tree, which was about twelve years old, reached the height of its production in 1905 when 4 lb. 12½ oz. of rubber was obtained.

The report of Mr. W. Peel, the Agricultural Superintendent of the Gardens, on the tapping operations during 1906, showed that though the old tree in the Botanic Gardens which was tapped 14 times between November 19th and December 15th, and gave 4 lb. 4½ oz. of dry rubber, the same number of operations on trees on Penang Hill, carried out between July 11th and August 6th, yielded only from 11½ oz. to 2 lb. 14 oz.

The following results* are of considerable interest, as they show the yield obtained by tapping trees of different ages on 12 alternate days by the herring-bone system:—

No.	Circumference 3 ft. from ground.		Age. Years.		Yield. Ounces.
1	..	17½ in.	..	3½	.. 1·54
2	..	26½ „	..	4	.. 2·26
3	..	26½ „	..	7	.. 14·27
4	..	39½ „	..	8 to 9	.. 16·76
5	..	—	..	10 to 12	.. 28·25

From these and other results Arden concluded that trees under four years were too young to be tapped, and that an average annual yield of 12 ounces per tree should be obtained from trees 6 years old. Other results have shown that an average of 3 lb. of rubber per tree per year, from trees in their 11th to 15th year, may be reasonably expected.

Two very old trees at Perak,† having a circumference of 56 to 80 inches respectively, and reported to be 25 years old, have given in two months' tapping no less than 12 and 18 lb. of dry rubber, including scrap.

* Report upon *Hevea brasiliensis* in the Malay Peninsula, Stanley Arden.

† India-Rubber Journal, February, 1903.

Other trees at Perak, 14 years old, have given an average yield of over 4 lb. each, and others of the same age quoted by Johnson show a yield of 3 lb. 1 oz. per tree in Malacca, and 6-year-old trees in Selangor 1 lb. 2 oz. per tree. The figure on one Plate shows a tree being tapped on the herring-bone system in Malacca.

Carruthers, in his Annual Report for 1906, gives some tables which show the development of rubber estates and the yields obtained on properties in various parts of Malaya. The following are extracts from the report :—

	Federated Malay States.	Straits Settlements.	Johore.	Total.
No. of trees tapped	441,488	27,076	48,350	516,914
Dry rubber extracted. Lb.	861,732	13,560	47,724	923,061

Carruthers states that the "average amount of dry rubber extracted per tree, calculated from the figures in the table, gives 1 lb. 12 oz. per tree. Many of the trees in the Federated Malay States are 10 years old" some over 20 years give a good deal more than 2 lb. a tree.

Dealing with parts of the Federated Malay States alone, Carruthers gives the following particulars :—

FEDERATED MALAY STATES.					
	Selangor.	Perak.	Negri Sembilan.	Pahang.	Total.
No. of trees tapped.	364,638	67,710	91,410	—	441,482
Dry rubber extracted. Lb.	620,033	94,848	146,891	3,645	861,738

The average yield of rubber from trees on a well-known property in the Federated Malay States was recently published.*

On this estate 150 trees 8 years old gave 525 lb. of rubber; 120 trees 7 to 7½ years old gave 250 lb. of rubber; 5,500 trees 6 to 6½ years old gave 4,041 lb. of dry rubber; and a further 6,000 trees, 5 to 5½ years old, gave 1,815 pounds of rubber; all the trees were tapped judiciously on the herring-bone system.

The Sandycroft Rubber Co., in their annual report for 1905, stated that 4,050 Para rubber trees were tapped during the first portion of the year, and these 4,050 trees were re-tapped 6 months later together with 5,238 other trees; the dry rubber from these tappings, totalled 6,979 lb. sheet and 1,823 lb. scrap, or a total of 8,802 lb. of rubber from 9,288 trees.

In Java, according to Dr. Tromp de Haas, there is a large variation in the yield of trees of the same age or from equal areas of bark on the same tree.

* India-Rubber Journal, August, 1907.

RUBBER YIELDS IN INDIA DURING 1906.

There are very few records of the yield of rubber in South India, but in an issue of the *Madras Mail* information was given regarding the growth and yield obtained on Hawthorne Estate, Shevaroy Hills. On this property the Para rubber is growing among coffee, at an elevation of 3,000 to 3,500 feet, and in a climate having only about 50 inches of rain annually. The photographs of the rubber on this estate show fairly good growth, most of the trees having been allowed to produce tall and slender stems. Early in 1906, 91 Para rubber trees, twelve of which were seven years old and the rest five and six years, were tapped, and an average yield of $\frac{1}{4}$ lb. of dry clean rubber per tree for one month was obtained. An estimate of 1 to $1\frac{1}{2}$ lb. of rubber per tree, per year, was given as the probable yield in the future, based upon the above results. In conjunction with this it must be remembered that at an elevation of 2,600 feet in Ceylon, in a relatively dry climate, a yield of 2 lb. of rubber per tree has been obtained during 1905.

On the Mergui Rubber Plantation, South India, tapping by the V method was recently carried out, and it was found that morning tapping gave much better results than evening tapping. The figures for the whole season show the average quantity of latex per incision, each 6 inches in length, obtained in the morning to be 3.54 c.c. compared with 1.89 c.c. in the evening. Tapping in the rains was found to give almost double the amount of latex per incision, namely, 6.62 c.c., but the yield of dry rubber per 1,000 c.c. of latex was much less, being 12.8 oz. as compared with 16.4 oz. from morning tapping and 15.1 oz. from evening tapping before the rains. The best season for tapping was found to be from October to February.

YIELDS IN THE GOLD COAST.

Four trees, 10 years old, were tapped for the first time in 1903, and yielded 4 lb. 3 oz. of dry rubber, or an average of 1 lb. $\frac{3}{4}$ oz. per tree. Notwithstanding the quantity of rubber extracted, Johnson states that the trees show no signs of having suffered in the slightest degree.

The amount of rubber yielded by the Para and African trees* may be compared by consulting the tables given below :—

	Num'ber of Trees tapped.	Age of Trees, in years.	Date of Tapping	Average yield of Rub' per tree. lb. oz.
<i>Hevea brasiliensis</i>	4	10	{ Nov. 1903 ... Dec. 1903 ... }	1 $\frac{3}{4}$
<i>Funtumia elastica</i>	1	7	Dec. 1901 ...	0 4
"	1	9	" 1903 ...	0 1
"	1	9	" 1903 ...	0 4

Regarding the yield from *Hevea brasiliensis*, Johnson remarks that it must not be taken as a criterion of the anticipated yield

* Johnson's Report on Rubber in the Gold Coast, 1905.

for trees of this age cultivated in West Africa, and points out that the trees referred to are growing in poor, gravelly soil on the top of a hill under unfavourable conditions.

YIELDS DURING 1906 AND 1907 IN CEYLON AND MALAYA.

The difficulty, pointed out elsewhere,* of accurately forecasting the yield of rubber obtainable from newly-planted trees in the East has always been recognized, and we are gradually gaining a more varied knowledge of the yielding capacities of the different species now under cultivation. During 1905 the general idea prevailed that the older trees of *Hevea brasiliensis* might be expected to yield an average of one pound of dry rubber per tree, per year, but since then many improvements have been made in tapping knives and systems of tapping.

We are now in possession of a large number of statistics which indicate the results obtained by well-known rubber companies in Ceylon and Malaya, during 1906, from trees which had been previously tapped or which had just reached the tapping stage. The young trees tapped for the first time in 1906 were from about 15 to 24 inches in circumference, 3 ft from the base; it is interesting to note that during 1906 the yield was rarely under one pound per year, and on most properties was nearer one-and-a-half to two pounds, per tree, per annum.

The following figures, referring to the yield per tree but not necessarily to the total yield from each estate, are of interest:—

YIELD PER TREE. †					
Company.		Yield in lb.	Number of trees tapped.	Average per tree, per year 1906	
Consolidated Malay	...	32,693	11,348	2.88	
Anglo American Direct Tea	...				
Trading	...	3,281	1,172	2.79	
Anglo Malay	...				
(a)	...	47,788	28,326	1.68	
(b)	...	28,697	14,123	2.03	
(c)	...	15,469	10,392	1.48	
(d)	...	8,064	8,240	0.97	
Blackwater	...	13,033	8,744	1.49	
The Kalutara Co.	...	8,126	4,379	1.85	
Kepitigalla (‡)	...	42,612	21,500	1.98	
Pelmadulla	...	602	500	1.20	
Yatiantota	...	8,790	4,636	1.89	
Shelford	...	6,805	9,636	0.70	
Sandycroft	...	16,178	13,046	1.24	
Ledbury	...	2,057	3,755	0.54	
Yataderiya	...	8,025	5,047	1.34	
Perak	...	16,327	12,600	1.31	
Bukit Rajah	...	118,982	88,341	1.34	

[Continued over.

* India-Rubber Journal, August, 1907.

† India-Rubber Journal, July, 1907.

‡ 15 months.

PARA RUBBER.

YIELD PER TREE.—*Contd.*

Company.	Yield in lb.	Number of trees tapped.	Average per tree, per year.
Vallambrosa			
(a) ...	12,765	4,642	2.75
(b) ...	54,451	36,301	1.50
(c) ...	6,225	6,225	1.00
(d) ...	70,820	70,820	1.00
(e) ...	9,097	29,113	0.31
Highlands and Lowlands			
(a) ...	95,333	38,639	2.46
(b) ...	5,742	807	7.01
(c) ...	38,952	39,874	0.97
Cicely ...	19,069	8,020	2.37
Kuala Lumpur	}	5,035	1.83
(Year ending June 30th, 1907)		3,598	2.33
.....		1,437	0.56
.....		9,466	3.16
Rubber Plantations			
(Year ending June 30th, 1907)	1,481	2,000	0.75
Pataling ...	...	39,336	1.10
Asiatics ...	8,045	5,271	1.5
Eastern Produce ...	22,558	20,735	1.08
Golden Hope ...	2,640	880	3.00
Union Estates ...	758	400	1.89
Bertram ...	19,781	16,782	1.2
Balgownie ...	10,642	8,000	1.33
Kalumpang Rubber Co. ...	16,271	14,500	1.1

YIELD PER ACRE.

In the reports of some companies the yield per tree is not given, but the total quantity of rubber from a given acreage possessing trees of different ages is of interest.

Company	Total yield lb.	Acreage tapped.	Yield in lb. per acre.
Kuala Selangor ...	3,222	57	57
Malay States Coffee Co., ...	10,918	144	96
Rubber Growers Co., ...	4,370	35	125
Selangor Rubber Co., ...	70,577	553	128
Seremban Est. Rubber Co., ...	62,258	412	151
Total	151,745	1201	Average 125

From these figures we learn that a yield of 125 lb. per acre, per year has been obtained from 1,201 acres.

TOTAL YIELDS FROM 1905 TO 1908.

It is common knowledge that the yields which have been obtained during the past year from Para rubber estates show a large increase over previous records. This increase in yield is, to a large extent, due to the various estates having increased the number of tappable trees; in some instances, however, an increased yield per tree has been noted. A few particulars, showing the increase in crops during the year on properties owned by companies who have made their results public are given below; in the majority

of instances Para rubber only is referred to, but to a few records the yields from *Ficus Elastica* trees have apparently been added.

TOTAL YIELDS FROM EASTERN ESTATES.

Company.	1905.	1906.	1907.	1908.
	lb.	lb.	lb.	lb.
Consolidated Malay ..	—	32,693	63,590	—
Highlands and Lowlands ..	—	134,285	193,505	—
Labu ..	—	—	22,000	—
Batu Caves ..	—	—	3,332	—
Linggi ..	—	—	102,000	17,000
Anglo Malay ..	—	100,019 (14 mos.)	224,150	(Jan. only) 47,532
Vallambrosa (year ending March 31st) ..	—	—	156,922	(Two months only) 204,389 (uptoFeb. only)
P. P. K. Ceylon ..	4,982	8,305	14,800	—
General Ceylon Rubber ..	—	10,574	20,000 (?)	—
Bukit Rajah (Year ending 31st March) ..	6,811	33,203	118,982	162,000
Ceylon Tea Plantations ..	3,685	7,132	—	—
Inch Kenneth (Year end- ing 30th June) ..	—	900	2,006	—
Klanang Produce ..	—	13,218	10,000 (uptoSept. 30th)	—
Pataling ..	25,699	43,310	—	—
Rosehaugh ..	45,090	89,594	167,000 (estimated)	—
Selangor ..	29,750	70,577	83,230 (9 months)	—
Yatiantota ..	8,212	8,761	5,841	—
Langkat Sumatra ..	—	—	—	1,000 (Jan. only)

F. M. S. RUBBER EXPORTS DURING 1907.

The following are the official figures:—

	Export 1907.	Export 1906.	Increase
Perak ..	255,530	149,640	105,890
Selangor ..	1,198,751	681,040	517,711
Negri Sembilan ..	530,004	198,112	331,892
Total ..	1,984,285	1,028,792	955,493

YIELD AND DISTANCE APART OF TREES.

For several years planters have not been able to decide the question of the best distance in planting, many believing that the closely-planted trees would yield more per acre than those widely planted. During 1906 some very good results were obtained on

estates where the trees were widely planted, and on closely-planted properties much difficulty was experienced in thinning-out the undesirable trees.

YIELDS ON VALLAMBROSA ESTATE.

The following statement of approximate yield from the older fields belonging to the Vallambrosa Rubber Estate Company was compiled from the manager's report and presented to the public by the Directors in their Annual Report for 1906:—

Acreage of fields	Distances trees planted apart.	No. of trees tapped.	No. of times tapped.	Yield per tree.	Total Yield.	No. of trees per acre tapped.	Yield per acre.	Remarks.
	Feet.			lb.	lb.		lb.	
60	24 × 12	4642	3	23 1/2	12765	77	212 1/2	Planted 1899 (about 150 trees per acre).
150	10 × 10	{ 8000 28301	{ 3 2 }	1 1/2	54451	242	363	This field was planted through coffee in 1898, and thinned-out to 260-270 trees per acre.
40	12 × 10	6225	2	1	6225	155	155	Planted 1900. Thinned to 250 trees per acre.
680	12 × 10	{ 10000 60820 29113	{ 3 2 1 }	1 oz. 5	{ 70820 9097 }	147	117 1/2	Planted from 1899 to 1901. Thinned to 250-270 trees per acre.
930		147101			153358			

YIELDS ON HIGHLANDS AND LOWLANDS ESTATE.

The Annual Report of the above Company for 1906 gives some interesting information in favour of widely-planted trees. The report made by Mr. R. W. Harrison states that there is one block of trees, 16 acres in extent, containing 807 trees planted 30 by 25 feet. These trees, nine years old, were tapped three times during 1906 and gave 2,500 lb. at the first, 1469 lb. at the second, and 1773 lb. at the third tapping; or a total of 5,742 lb. from 807 trees, equivalent to a yield of over 7 lb. per tree. These may be exceptional results, but they certainly indicate that satisfactory returns can be obtained when the trees are not closely planted.

As pointed out by Etherington, the distance of 30 by 25 feet allows 2,250 cubic feet of soil to each tree and an average spread of foliage of 750 square feet; under these conditions the food-producing and absorbing power of each tree must be considerable.

YIELDS AT SINGAPORE.

Ridley and Derry in their Annual report for 1904 published some figures showing ratio of yield to the size of the tree.

The following table was given:—

		Comparative yield per inch of girth at 3 feet from ground.	
Girth at 3 feet from ground.		Under	$\frac{1}{4}$ oz.
Under 2 ft. girth	...	...	$\frac{1}{4}$ oz.
From 2 ft. to 2 ft. 6 in.	...	Under	$\frac{1}{2}$ oz.
From 2 ft. 6 in. to 3 ft.	...	...	$\frac{1}{2}$ oz.
From 3 ft. to 3 ft. 6 in.	...	Over	$\frac{1}{2}$ oz.
From 3 ft. 6 in. and over	...	...	$\frac{1}{2}$ oz.

Ridley and Derry believe that the best growing period is between the 6th and 15th years, during which time trees may increase from about 24 inches in girth to 60 inches or more, thus showing an annual increment to growth from 3 to 6 inches. They claim to have shown that trees closely planted do not make a satisfactory increment of growth, and that the yield of rubber increases with the size of the tree from under $\frac{1}{4}$ oz. of dry rubber to the inch of girth for small trees to over $\frac{1}{2}$ oz. for large ones; to further emphasize the error of close planting they have submitted the following statements taken from the figures of their experiments:—

No. of trees tapped.	Average girth per tree. ft. in.	Aggregate girth. ft. in.	Dry Rubber. lb. oz.	Remarks.
40	2 3	90 $\frac{1}{2}$	18 $\frac{7}{8}$	Tapped 18 times.
20	4 2	83 $\frac{1}{4}$	25 6	
50	1 9	88 $\frac{1}{4}$	18 $\frac{8}{16}$	
15	5 8	85 $\frac{1}{4}$	33 8	

COST OF PRODUCTION.

The cost of production on several small estates possessing trees of different ages, often scattered over a large acreage, is relatively high, but already there are indications that the latex from old trees may in the future be harvested and converted into rubber, at a cost of about 1s. to 1s. 6d. per lb. of dry rubber. The following details* are of interest, since they show the cost of production on several properties during 1906:—

Company.	Cost of Production.
Asiatic Rubber and Produce Co.	Rs. 0·97 cents.
Highlands and Lowlands Co.	0·25 " (dollar)
Pataling Rubber Estate	6·3d.
Vallambrosa	1s/
Vogan	Rs. 0·90
Yatiantota	1s/7½d.
Seremban Estate	Rs. 1·61

The Kuala Lumpur Rubber Co., Ltd., in their report ending June, 1907 state that on Wardie-burn the cost of collecting and curing was 31·14 cents (dollar) per lb. and on Kent 24·4 cents per lb. The cost of despatch of rubber from the estates to Europe was 10·4 cents per lb.

* India-Rubber Journal, August 26th, 1907.

The Balgownie Rubber Estate Co., in their report for the year ending 31st March, 1907, state that the cost for rubber tapping and curing was 7,217 dollars; the crop was 10,642 lb.

ANNUAL INCREASE IN OUTPUT FROM ESTATES.

The yields obtained from some estates during the past few years are small but show a gradual increase from the same properties as the tapped trees get older and more young ones attain a tappable size and age. The gradual increase is exemplified in the yields obtained on Gikiyanakanda, Neboda, Ceylon, according to the information kindly supplied to me by Mr. Gollidge, at my request.

GIKIYANAKANDA.

Year.		Yield per tree from young and old trees. lb.
1903	...	0.59
1904	...	0.76
1905	...	1.32
1906	...	1.78
1907	...	1.86
1908	...	8,175 lb. from 11,694 trees.

(1st Jan., to 4th April.)

ESTIMATE OF YIELD.

From these and other considerations it is obvious that to offer an estimate of the yield from trees of known age, one must be conversant with the climate and soil conditions, the available tapping area, the trees, and the method and care adopted in tapping operations. The results warrant the conclusion that trees from four to six years onwards, having a minimum circumference of 20 inches, may be expected to yield an average of one to three lb. of dry rubber per tree each year up to their 10th year, and a higher yield in subsequent years. The adoption of better systems of tapping, which obviate the necessity of paring away the tissues wherein the milk accumulates, and drawing supplies of latex by merely cutting and not excising the laticiferous tissues, is bound to result in an increased yield, since the life of the tapping area is so much prolonged. The fact that a few well-developed trees have been made to give as much as 12 to 25 lb. of rubber per year, and promise abundant yields in the very near future, shows what a tremendous amount of material there is to draw upon, providing the environs of the plant and tapping operations are fully understood. The heavy yields reported in one part of this chapter are, however, from exceptional trees, and when forming an estimate of the average yield over a large acreage may be neglected.

The reader is referred to the details given in the present chapter, showing the yields obtained from Ceylon and Malayan properties during 1905, 1906, and 1907, and those giving the yield of rubber per square foot of cortical tissues removed, if he is anxious to form an estimate of the rubber obtainable on an estate where the available tapping area and bark thicknesses are known.

CHAPTER XI

EFFECT OF TAPPING ON THE TREES.

Effect of repetitional bark stripping—Danger of annual cortical stripping—Excision of Rubber and Cinchona cortex—Excision and Incision—Pricking and paring in Ceylon in 1908—Effect of tapping on the foliar periodicity of the trees—Effect of tapping on size and number of seeds—Frequent tapping and reduction in yield of rubber—Frequent tapping and quality of rubber—Time interval required for accumulation and concentration of latex—Reduction in percentage of caoutchouc in the East—Schidrowitz and Kaye on an abnormal latex with low caoutchouc contents—Stevens on caoutchouc in latex from 6 and 7 year old trees—Time interval for maturation of cortex.—Rate of bark renewal in Ceylon—Rate of renewal on crowded estates and in inferior soils—Thickness of renewed bark at Gikiyanakanda—Thickness of renewed bark, 3, 15 and 36 months old—Thickness of renewed bark two years old, at Henaratgoda—Formation of rubber in situ.

THE EFFECT OF REPETITIONAL BARK STRIPPING.

IT is common knowledge that many of the excessive yields have been obtained by completely excising the whole of the bark tissues from the base up to a height of six to fifteen feet, and it is natural that some questions should be put forward as to the probable effect of such treatment on the plants.

At the outset it must be recognized that the great function of the cortical or bark tissues is to conduct the elaborated food materials produced in the leaves, *from above downwards*, to various sections of the growing plant, and also to store up, in certain of its cells, a quantity of food as reserve material. As a store house and conducting channel it is of vital importance to the plant, and if it is removed too quickly the life of the tree may be endangered. The internal wood, though of great importance to the plant in conducting, *from below upwards*, the water and mineral food absorbed by the roots, is less vital than the cortex, and the internal portion may, to a certain extent, be dispensed with without very seriously injuring the tree. The cortical tissues are dependent for their renewal on the activity of the cambium—a delicate tissue separating the inner cortex from the

wood—and in the natural course of events gradually dry up near the surface and peel off in the form of dead bark. The inner cortex, originally containing the latex tubes, is therefore ultimately cast off as dead bark, so that it may be said that cortical stripping, in tapping operations, is one way of expediting the removal of the bark tissues and may be effected without seriously disturbing the execution of the normal functions of the plants.

It must be obvious to every one that the stripping of the bark, as executed in tapping, is an unnatural process and not exactly comparable with the same phenomenon in nature. It differs from the natural process in so far that the cortical cells are excised while they are in a living condition, and are entirely removed at a time when they contain reserve food intended for the use of the plant; it also differs from the natural process in so far that the average operator exposes the inner, more delicate, and vital tissues of the cortex and cambium to atmospheric influences. Such treatment does affect the vigour of the trees, and if carried out too frequently may hasten the death of the plants. Under these circumstances it may be suggested that the complete stripping of the bark, *every year*, is a forward but dangerous plan on which to work. The writer has seen many trees which are not thriving under such a treatment, and is inclined to recommend it only in cases where thinning-out of the trees is desired. On many estates where the parallel tapping lines or areas are originally planned out twelve inches apart, the bark is excised at the rate of one inch per month, which means complete stripping in a year; on other properties an inch is made to last from two to four months.

EXCISION AND INCISION.

If the area is excised at such a rate that the whole of the bark is removed in three years, the oldest renewed tissue, by the time it can again be tapped, may be considered near maturity, and can be operated on with comparative safety. Three to four years is near the minimum time required for the young plants to produce what is considered mature bark, *i.e.*, fit for tapping. The suggestion for less rapid excising is made from a study of the observed effect on Para rubber trees in Ceylon; it is a question whether it would not be better to only excise the bark tissues when fresh areas are required for the use of the pricking instrument. It is very doubtful whether the paring of the bark should be looked upon as the one and only operation required to obtain a flow of latex; it might, perhaps, be better regarded as a means of facilitating the collection of the latex obtainable by incising and not excising the milk tubes.

The effect of paring away the outer bark and exposing the internal and more delicate structures to atmospheric influences has in some cases been detrimental. In a particular case in mind

the inner tissues dried up and peeled off in flakes, exposing the whole of the wood. This effect is more noticeable on Ceara rubber trees, but is also known to occur on trees of Para rubber. It has been suggested that a covering of some waterproof material or of any substance which, while affording protection from rain or sun, will not harbour insects, might be used to cover the tapping area or renewed bark when collecting operations have been completed. The covering might be arranged loosely in the form of a mantle or be wound round the oblique excised areas like an ordinary "puttie" for one's legs.

PRICKING AND PARING IN CEYLON IN 1908.

I was agreeably surprised to observe the frequency with which trees were being pricked on the occasion of my visit to several well-known Kalutara estates in April, 1908. On two plantations, where a year ago only the paring operation was adopted, the pricking implement was used as soon as the flow following the paring operation had ceased. On another estate latex was never deliberately obtained by paring; every evening the coolies went round to collect the serap coagulated in the tapping lines and gently used the paring knife to remove only the outer dead bark and expose a new area below for the pricker; on the following morning the pricker was used on this fresh area and the day's latex thereby obtained. By such a method great economy in bark is effected and the risks accompanying the deep paring method are obviated to a large extent.

EFFECT OF TAPPING ON THE PERIODICITY OF THE TREE.

The treatment meted out to Para rubber trees may be said to be less drastic than that adopted in rapidly excising or peeling the bark and cortex off cinchona trees, and not as rigorous as the cutting off of the stems of cinnamon bushes near the base in order to subsequently secure the dry peeling bark; nevertheless, where latex extraction is inseparable from rapid cortical stripping, the processes remind one of those adopted, in the past, on many cinchona plantations.

Then what are the probable effects on the trees which have been tapped in this manner? It may be considered too early to form any definite conclusions, but what may be regarded as the early effects of extracting latex, and cortical stripping, should be recorded.

The most striking effect, even on estates where there has been but little excision of the cortex and where the latex has been mainly obtained by the use of pricking instruments, is that on the foliar and other periodicities of the plant. Several tropical trees even though they are growing in the same garden often show

considerable differences in foliar periodicity; but untapped trees of *Hevea brasiliensis* growing under approximately the same physical conditions do not generally show very conspicuous differences, as the tabulated results, given elsewhere, have shown.

TAPPING AND CHANGE IN FOLIAR PERIODICITY.

Tapped trees do, however, show much variation; the leafless phase of heavily tapped trees may be passed through during different months of the year. It has been shown elsewhere that the foliar periodicity of endemic, indigenous and even introduced trees in Ceylon is mainly determined by the humidity of the air and soil, the majority of the trees passing through their leafless phases during the period when least moisture is available. A change in foliar periodicity is coincident with changes in humidity and it appears quite possible that the extraction of latex, involving the removal of almost half its weight in water may, from moisture changes alone, be partly responsible for some of the changes in foliar periodicity. If the change was only more general this conclusion would be more justifiable; it is the constancy in all periodicities of some heavily tapped trees of *Hevea brasiliensis* which prevents one from making a definite statement on this point.

The changes in foliar periodicity, produced by deliberately mutilating parts of the tree, are only too well-known; probably much of the change in *Hevea brasiliensis* is due to the interruption in the work of the conducting and store cells of the cortex, rather than the removal of water in the latex. If this is the case the interruption may lead to further irregularities, to a lessening of the vigour of the plant, and even hastening the decay and premature death of various parts. Reports have been frequently received to the effect that the size and number of the seeds produced have been reduced on some trees, and in particular instances an increase in number of seeds per tree has been noted; the latter is probably suggestive of more danger than the former.

FREQUENT TAPPING AND YIELD OF RUBBER.

That too frequent tapping may lower the yield of rubber there can be no doubt. It has been previously pointed out* that results of experiments outlined to determine quite different points have shown a common agreement in so far that, when tapping has been done too frequently or too extensively the yield of rubber has been reduced, and the bark or source of future latex has gone. In some cases the poor yield from well-developed trees can be associated with the too rapid excising of the bark, and the sooner one realises that the bark is really the "mother of rubber", and that its rapid removal means a reduction in subsequent yields, the better for all concerned.

* Science of Para Rubber Cultivation: **MOSSERS A. M. & J. Ferguson.** Colombo: 1907.

One might at first conclude that, since the Para rubber trees rarely ever run absolutely dry, and most of them (no matter how roughly they have been handled) appear to contain an inexhaustible store of latex, the more frequently the trees are tapped the larger the quantity of rubber obtainable. In one series of experiments, which may or may not be exceptional, this idea was disproved. The trees in one area were tapped every day from September, 1905, and those in another group every alternate day from the same date. The trees which were tapped every day (on 264 occasions) have given about 9 lb. of dry rubber each, and all the original bark had been cut away; those trees which had been tapped every alternate day (on 131 occasions) gave about 11 lb. of dry rubber each and only half of the original bark was removed. The illustrations will help to make this clear.

I inspected these trees in April, 1908 (about two years after the experiments) and was convinced that tapping every day was extremely dangerous and one likely to materially affect the future life of the tree.

Tapping at less frequent intervals did not only give a higher yield of rubber per tree, within exactly the same period, but there was sufficient original bark remaining to last for another nine months on each tree. The labour expenses were reduced; the yield increased, and the trees less drastically treated by tapping every alternate day instead of every day. There is some ground for believing that, when incision of the latex tubes is made more perfect than at present, the interval between each tapping operation may, with advantage, become still longer and yet be accompanied with a further increase in yield and saving of labour. In view of the enormous variation in the yielding capacity of bark of the same tree and the composition of the latex from the same area, it would be unwise to regard these results as being always possible; they are, however, worthy of consideration and may form a basis for further research.

FREQUENT TAPPING AND LOWERING OF QUALITY.

The inferiority of some samples of plantation rubber may be partly due to the caoutchouc and other constituents being immature. The quality of rubber from the same trees in Ceylon varies from time to time. The rubber from the first tappings is more apt to become soft and tacky than that procured some time later; that from the same trees may, when obtained during the first two or three months' tapping, be of excellent quality, but after a time the quality often deteriorates. The deterioration in the rubber obtained after prolonged and repetitional tapping of primary bark, or in that secured from young renewed bark, can probably be accounted for by the changed physical and chemical composition of the latex. The latex obtained under these circumstances possesses a lower percentage of caoutchouc

and other ingredients and seeing that in the renewed bark all the constituents have arisen within a brief period of one or a few years, they can hardly be expected to have attained the same degree of maturity or strength, as those in the primary bark of older trees. In the Brazilian and African forests the trees and vines are only tapped during certain seasons and a long interval is allowed to elapse which may be partly responsible for the characters of the rubber secured.

The variation in the characters of the components of latex is considerable, especially if one considers different aged parts of the same tree, latex often being abundant in the younger parts, but so constituted as to be uncoagulable. The association of the strength of the final product with the frequency of tapping should be borne in mind and cause planters to hesitate before tapping too frequently or too rapidly destroying the original bark during collecting operations.

REDUCTION OF CAOUTCHOUC.

In the discussion following the lecture* given by the writer at the Ceylon Rubber Exhibition it was pointed out, that the percentage of the caoutchouc in latex might vary from 10 to 32, the latex from trees which had been too frequently tapped usually possessing a very large proportion of water. The caoutchouc is derived from compounds which have been identified in various parts of the plant, but as its production involves a complicated series of chemical changes, a certain time interval must be allowed for the accumulation of the globules and for a particular degree of concentration to be attained.

Ridley, in his Annual Report for 1906, states that in a trial of the spiral method of tapping, he obtained, from a tree in the Singapore Botanic Garden, from the first period of tapping 531 fluid ounces of latex giving 9 lb. of rubber, and from the second tapping, one month afterwards, 433 ounces of latex giving 4 lb. 15 oz. of rubber.

ABNORMAL LATEX FROM CEYLON.

Messrs Schidrowitz and Kaye have pointed out, in the "India-Rubber Journal" of July 1st., 1907, that in a sample of *Hevea brasiliensis* latex from Ceylon "the amount of rubber contained was abnormally small. The weight of the crude rubber obtained from 750 cc. of latex, after pressing, amounted to only 35 grams, or roughly 4.6 per cent. Allowing for moisture, this would mean that the latex in question contained barely 4 per cent. of dry rubber. The latex, it may be said, was obtained from the primary

* Science of Para Rubber Cultivation, Messrs. A. M. & J. Ferguson-Colombo, 1907.

bark of a five year old tree, tapped in a normal manner, and we are not in a position to offer an explanation of the exceedingly low caoutchouc contents." They do not state, however, what quantity of liquid was added when the latex was first bottled in Ceylon.

Stevens following on this point states * that he has also made "some tests with separate quantities of latex from Ceylon, to which small quantities of preservatives had been added. In these cases only small yields of caoutchouc were obtained."

"The latex was obtained from trees 6 and 7 years old, and represents either the first or second year's tapping. The contents of the different bottles did not represent the same mixture of latices, but were filled up from different trees as the latex came to hand. I am given to understand that no water was at any time added to the latex. The preservatives added were "cyllin" formaline, mercury salt, and chloroform.

The following figures were obtained :—

PRESERVATIVE.				YIELD OF MOIST CAOUTCHOUC.	
Cyllin	..	1	in 500	..	8.4 per cent
"	..	1	in 1000	..	8.8 "
"	..	1	in 2000	..	9.2 "
"	..	1	in 3000	..	10.0 "
Formaline	..	1	in 1000	..	8.6 "
Mercury salt	..	1	in 2000	..	10.0 "
" "	..	1	in 10,000	..	9.7 "
Chloroform	..	1	in 12	..	13.5 "

When allowance is made for the moisture, which is probably not less than 10 per cent., it will be seen that with one exception the yields were in all cases less than 10 per cent reckoned on the original latex." In these instances, the latices examined by Messrs Schidrowitz, Kaye and Stevens, do not appear to have been derived from any specially tapped trees and may indicate the variability of the composition of the latex rather than the effect of excessive tapping.

RATE OF BARK RENEWAL IN CEYLON.

The rate at which the bark of tapped trees renews varies considerably. Generally the renewed bark forms at the most rapid rate on trees grown alone and at a wide distance from each other; it renews very slowly on closely-planted trees, and on those which have been planted in poor soil or where associated with intercrops. The bark does not renew quickly when the root growth of the trees is checked by the roots of other plants and some surprising results may yet be recorded from estates with crowded mixed products.

* India-Rubber Journal, London, July 15th, 1907.

On young trees the renewed bark is often bulging and convex in outline and within a few months may attain the same thickness as the primary untapped bark. On older trees which have been deeply pared a longer interval is required for the renewed bark to grow to the same thickness as the untapped areas.

Measurements made in April, 1908, showed that on Gikiyanakanda estate, the renewed bark, on a nine-year-old tree grown on poor soil, was when three years old, $\frac{4}{16}$ to $\frac{5}{16}$ of an inch in thickness.

The following measurements were also made on an estate in the South of Ceylon, in April, 1908:—

Nature of bark.	Age of renewed bark.	Thickness of renewed bark.	Height from ground of point of measurement.
Second renewed bark.	2 months.	$\frac{7}{16}$ inch.	Base
Second renewed bark.	15 „ ..	„ „	5½ feet.
First renewed bark.	36 „ ..	„ „	5 feet.

These measurements were made on a tree, 14 years old, with a girth of 71 inches a yard from the ground. The remnants of primary bark above the tapping area had an average thickness of about $\frac{5}{8}$ so that the renewed bark three years old, appeared to be equal to the original. The tree has given 15 lb. of rubber in 4 years.

Another tree 4½ years old, had its renewed bark $\frac{3}{16}$ in thickness though only two months old; this was nearly equal to the thickness of the primary bark above the tapping area.

The old Henaratgoda trees, measuring 68, 56, 29, and 18 inches a yard from the ground, had renewed bark about two years old measuring $\frac{5}{8}$, $\frac{4}{8}$, $\frac{3}{8}$, and $\frac{2}{8}$, of an inch respectively, in thickness.

The bark renews fairly rapidly on the majority of the trees but the latex takes longer to mature.

FORMATION OF RUBBER IN SITU.

No one has yet determined the total quantity of rubber procurable from the whole of the bark of a Para rubber tree of known age or size by felling the tree and macerating the milky tissues. But it is well-known that, irregularly connected though the laticifers in this species may be, the quantity of rubber procurable by tapping may greatly exceed the actual weight of bark removed even when a wasteful excision method is adopted. It is therefore obvious that the rubber must be formed in the bark in virtue of the associations of the laticifers with other parts of the plant which permit of the circulation of ingredients ultimately forming part of the latex. The laticifers in the bark are usually surrounded by cells which either store food supplies or conduct the sapelaborated in the leaves from above downwards; their walls are very thin and the permeation of solutions from the surrounding cells is easily accomplished.

Whenever laticifers are cut it is obvious that they must partially drain those with which they are connected and, after closing, again become filled partly with the latex from connected laticifers. At the same time certain cortical cells, which have been cut off from the cambium in the usual manner, are gradually converted into laticifers which themselves become charged with latex; it is impossible when examining young cambium products to distinguish which cortical cells will form laticifers in the secondary cortex.

In order to determine whether caoutchouc is developed at the place where it is collected from the tree, experiments are now being made (Tropical Agriculturist, September, 1907); "trees are being ringed, and half-ringed, at distances of a foot, and all the milk removed, to determine whether new rubber is formed between the rings." The results of these experiments will be awaited with interest. In April, 1908, the isolated cylinders of bark possessed a fair quantity of latex.



CHAPTER XII.

PHYSICAL AND CHEMICAL PROPERTIES OF LATEX.

Physical properties of latex—Colour, consistency, alkalinity—Sap exudations and acidity—Object of producer—Mechanical impurities—Water in latex—Chemical Analyses of latex of Para rubber by Seeligmann, Scott and Bamber—Variation in Chemical composition—Caoutchouc globules—Occurrence, size, density and Brownian movements—The origin of caoutchouc in plants—Resins and Sugary substances in latex—Protein matter in latex and putrefaction—Mineral substances in latex and their influence in coagulation—Specific gravity of latex—General characters of latex—Effect of temperature, ammonia, formalin and acids.

THE PHYSICAL PROPERTIES OF LATEX.

THE latex of *Hevea brasiliensis*, as it flows from a freshly made incision, is white or pale yellow in colour, and varies in consistency mainly according to whether drought or rainy weather prevails. It is slightly alkaline when fresh, and, as it flows from the tree, consists of minute globules of caoutchouc and other bodies suspended in a liquid containing various materials in solution and a varying proportion of mechanical impurities.

The latex obtained from the first incisions usually contains a large proportion of sap exudations, which cannot be excluded as they flow from the freshly-cut cortical cells; they can be reduced by incising instead of excising the laticiferous tubes. In several instances the latex, by mixing with such exudations, becomes neutral, and may rapidly develop acid properties. The conversion to an acid state is followed by coagulation, and hence the first tappings are frequently but unavoidably accompanied by a large proportion of scrap.

The object of the producer in the Tropics is to separate the globules of caoutchouc from the mechanical impurities and some of the materials in solution; it is, therefore, necessary to explain clearly what these substances are and their general characteristics.

The planter, who aims at producing the highest quality of rubber or perfecting the chemical and mechanical processes involved in its manufacture from latex, must thoroughly grasp the nature of the substances he has to deal with.

The mechanical impurities present in most samples of latex in the field consist of pieces of bark, fibre, sand, &c., and may be easily separated by filtering the diluted solution through butter cloth or fine gauze.

The filtrate from such material is composed of water, caoutchouc, resins, proteins, sugars, gums, insoluble substances, and mineral matter. The amount of water in pure latex varies considerably, but it is usually estimated at 50 to 56 per cent. The latex from trees which have been frequently or heavily tapped usually contains a much higher proportion of water; in some instances even as much as 90 per cent. of water is present. The latex collected during the dry months of February and March at Henaratgoda contains much less water than that obtained from the same trees in the rainy season. The following table will serve to indicate the general range in composition according to the analyses of Seeligmann,* Lascelles Scott, and Bamber †:—

CHEMICAL ANALYSES OF THE LATEX OF *HEVEA BRASILIENSIS*

	Seeligmann. per cent.	Scott. per cent.	Bamber. per cent.	Bamber. per cent.
Water ..	55 to 56	52-32	55·15	55·56
Caoutchouc or india- rubber ..	32	37-13	41·29	32·00
Protein or albuminous matter ..	2-3	2-71	2·18	2·03
Resin ..	Traces	3-44	—	2·03
Ash ..	..	0-23	0·41	..
Sugar ..	..	4-17	0·36	..
Salts ..	..	..	..	..
Essential Oils ..	9-7	Traces	..	..

The above analyses show the general composition of the latex of *Hevea brasiliensis* and the different classifications adopted by chemists. The analysis by Lascelles Scott is one of a latex of unnamed origin, but Weber accepts it as being not far from the truth for our species. There is an indefiniteness about several of the constituents, grouped under such general heads as proteins, resins, etc.

The latex from parts of the same tree at different times of the year shows considerable variation, and minor ingredients, which are normally absent, appear on certain occasions. It has also been shown elsewhere how the composition and character of the latex varies from the same tree during different parts of the same

* India Rubber and Gutta Percha, by Falconet, Seeligmann, and Torrilhom, 1903, p. 84.

† Bamber, Circular R. B. C., June, 1899, and Ceylon Rubber Exhibition.

season, according to the frequency of tapping, conditions of humidity, and the age of the cortex whence the latex is extracted. Schidrowitz, Kaye, and Stevens have shown how certain samples of latex from trees of *Hevea brasiliensis* in Ceylon vary and have pointed out that in those which they characterised as abnormal only from 4 to 10 per cent. of caoutchouc occurred.

It will be noticed that the caoutchouc, according to the above analyses, varies from 32 to over 41 per cent., and the other constituents such as resin, sugar, insoluble substances and ash show considerable variation. This is not surprising, as the latex examined in each case was obtained from a different country and the ages of the trees were probably quite different. Furthermore, the methods of extraction of the latex involve the cutting of bark tissues to different depths, and the inevitable mixing of liquids would account for much variation in the soluble impurities.

CAOUTCHOUC GLOBULES.

The caoutchouc exists as globules in suspension. When pure it is practically colourless, and is much lighter than water. It consists essentially of carbon and hydrogen, and belongs to a class of bodies known as terpenes. It is insoluble in water, but, according to Weber, may be obtained fairly pure by making a benzene solution, allowing the insoluble matter to settle out, and subsequently precipitating the rubber from the clear solution by the addition of alcohol.

The caoutchouc globules of *Hevea brasiliensis* vary considerably in size; their density varies from 0.914 to 0.986, at 16° C.

Henri states that microscopic examination of the latex reveals the presence of a large number of globules some with a diameter of nearly 0.002 millimetres, others smaller, the latter exhibiting extremely intense and persistent Brownian movements. The number of globules in a latex indicates its richness and may be easily determined: in the operation a suitable diluent—20 per cent. solution of sodium chloride—is added, which arrests the Brownian movements, without precipitating or coagulating the latex: the globules can then be counted and in one case an average of 50 million globules per cubic millimetre was counted.

ORIGIN OF CAOUTCHOUC.

The production of caoutchouc in latex has been investigated and it is generally admitted that Harries has fairly well established the relation of the caoutchouc to the sugar-like products—levulinic acid—in the plants; this is a subject which might well occupy the attention of chemists in the tropics who have unlimited supplies of fresh latex and laticiferous plants at their command.

RESINS AND SUGARY SUBSTANCES.

The resins, gums, and oil substances are present in varying quantities. Generally the latex from young trees, branches, and twigs contains a large proportion of these substances; they may occur as globules suspended in the latex or in solution. In the ordinary processes of coagulation the greater part of the resin becomes part and parcel of the rubber, and the extraction from the latter by the manufacturers in Europe is a difficult and tedious task.

The sugars are rarely present in large proportions, and a maximum of 0.5 per cent. may be taken as correct. They are known as inosite,* bornesite, matezite, and dambinite, and are dissolved in the liquid in which the globules of caoutchouc and resins are suspended: in the washing of the freshly-coagulated rubber they are generally removed.

PROTEIN MATTER.

Our knowledge of the chemistry of the proteins in latex is not very clear, especially in regard to the soluble nitrogenous products which remain in the mother liquor after coagulation; these are probably quite different from the complex proteins which are coagulated and form part of ordinary raw rubber. Spence states † that though the nitrogenous products which occur in the latex after coagulation are peculiar in origin and constitution they are in all probability simple products of protein metabolism.

The protein or albuminous matter, about which more will be said, varies from 1.9 to 2.7 per cent. of the fresh latex, or approximately 3 to 4 per cent. of the dried coagulated product. This is a very high proportion, but from the analyses quoted above no other conclusion can be drawn. It is believed that this protein matter is of a complex nature, and, alone or with the gums and sugars, is responsible for the development of bacteria on the finished product, which lead to putrefaction or "tackiness." The use of formaldehyde in connection with the elimination of the protein matter will be considered when dealing with coagulation.

When the rubber is prepared by simple coagulation the insoluble protein becomes a part of the rubber, but if a centrifugal method is adopted, and the freshly-coagulated material frequently and well washed, pressed and dried quickly, a considerable amount may be removed or rendered less harmful. In the purification of rubber this subject will be dealt with. It is believed that the removal of the protein from commercial rubber, though perhaps desired, is almost impossible, and in the perfecting of mechanical processes and the use

* Weber, *l. c.*, p. 2.

† India-Rubber Journal, August 16th, 1907, and Quarterly Journal of the Liverpool University.

of antiseptic reagents for dealing with the protein in the latex as it comes from the tree lies a considerable amount of important profitable work for planters in the Tropics.

MINERAL MATTER.

The inorganic matter found in most latices consists of compounds containing calcium, potassium, iron, sodium, and magnesium; these are combined with mineral or organic acids. The concentration and nature of the salts found in the latex influence its coagulation.

The mineral matter occurring in suspension and solution in the latex, and the various insoluble compounds indicated in the analyses previously quoted, may be regarded as impurities of minor importance, and can be better dealt with in the sections concerned with the components of commercial rubber and the purification processes.

SPECIFIC GRAVITY OF LATEX.

The chemical composition of latex varies considerably and a difference in specific gravity is therefore to be expected. Muspratt gives the density at 1.012; Ule quotes 1.041; Henri 0.973; Seeligmann 1.019; while Bamber states that the specific weight of latex of *Hevea brasiliensis* containing 32 per cent. of caoutchouc is 1.018 at 60 F. The density of the caoutchouc itself varies though the differences observable in that compound are insignificant when compared with those of the mineral, protein, or resinous contents.

GENERAL CHARACTERS.

The behaviour of the latex, when subjected to physical and chemical agencies, may here be touched upon. It readily mixes with water without creaming. Parkin kept some latex diluted four times in an ice chamber for days without showing any signs of creaming. It is very difficult to separate the caoutchouc by centrifugal force and on several occasions a speed of over 10,000 revolutions per minute did not effect a separation of the caoutchouc of normal latex. The effect of freezing was tried by Parkin, a mixture of ice and common salt being used to give the low temperature; after thawing, the latex appeared to be the same as before, and creaming was not hastened by the changes of temperature. Addition of ammonia or formalin prevents or delays coagulation, the former by neutralizing the acids as soon as they are formed, and the latter by acting as an antiseptic and preventing the decomposition of the protein matter. Acids bring about coagulation in the cold, but the action is much quicker when warmed. The latex may, however, if diluted, be boiled and yet coagulation is not brought about.

These points should be borne in mind by the planter who is inclined to experiment mechanically and chemically with the object of extracting the undesirable substances usually present in latex.

CHAPTER XIII.

THE PRODUCTION OF RUBBER FROM LATEX.

Straining latex—Use of porous cloth and centrifugal machines—Not largely used in Ceylon—Description of centrifugal machines in Ceylon—The phenomenon of coagulation—Behaviour of latex from different species—The Theory of coagulation—Henri's work—Phases of coagulation—Effect of reagents on latex—Torrey on the structure of crude rubber—Proteins and coagulation—Opinions of Dunstan, Spence and Weber—Proteins and Funtumia latex—Natural coagulation—Artificial methods of coagulation—Spontaneous coagulation—Natural heat—Addition of water—Addition of plant juices—Smoking and coagulation—Native method in Brazil—Palm nuts and plants to use in smoking—Patent smoking processes by Kerckhove, Brown & Davidson, Macadam, Wickham and Da Costa—Use of alcoholic solution and creosote—Coagulation by chemical reagents—Use of acetic, formic and tannic acid—Mercuric chloride—Cream of tartar—Amount of acetic acid to be used—Amounts used on Culloden and Gikiyanakanda—Time required for coagulation—Method of determining the amount of acetic acid required—Advantages and disadvantages of adding chemicals to the latex—Influence of coagulant on strength of rubber—Physical properties of rubber prepared by various methods—Relation of elastic properties to structure of the coagulum—Observations by Henri, Spence and Torrey—Components of coagulated rubber—Putrefaction and tacky rubber—Analyses of sound and tacky rubber by Bamber—Use of antiseptics—The necessity for washing rubber—Removal of the proteins from latex—Experiments with *Castilleja*—Experiments with Para rubber latex—Uses of ammonia and formalin—Rapid coagulation and removal of proteins by mechanical means—Biffen's centrifugal machine—Experiments in Ceylon—Aktiebolaget Separator—Michie-Golledge machine—Matthieu's apparatus—Harvey's coagulator—Coagulation in the field or factory.

HAVING briefly described the physical and chemical properties of latex as it is obtained in the field, it now remains for us to consider the operations upon which the production of good rubber from latex depends. If pure latex is allowed to stand in a receptacle, it finally coagulates and the caoutchouc globules with other substances float to the top, leaving a more or less clear liquid behind.

By the addition of chemical reagents or by subjecting the latex to different temperatures coagulation may be hastened or retarded. The coagulated substance after washing, pressing, and drying is ultimately known as the rubber of commerce.

In the production of rubber from latex the planter may either take advantage of the presence of coagulable constituents in the latex or adopt chemical and mechanical means for the separation of the caoutchouc globules from the rest of the latex.

STRAINING LATEX: CENTRIFUGAL MACHINES.

But before any steps are taken to effect coagulation the planter should see that the latex is quite free from any mechanical impurities; it is first necessary to filter the latex through porous cloth or remove the visible impurities by means of some mechanical apparatus. At the Ceylon Rubber Exhibition two centrifugal machines were exhibited for this work and the following is the account of Mr. Hyde in the Official Handbook of the Exhibition.

“Both machines are rotary, and with the exception of the central basket or drum, are of the same design, but with the one type of drum only the larger and lighter impurities can be removed, whilst with the other type only those particles of sand and grit etc., are eliminated which are of a greater specific gravity than that of the latex.

“Mr. Macadam’s exhibit, *i. e.*, the one which removes the larger and lighter impurities from the latex is a 12-inch self balanced centrifugal machine with a rope drive; it is composed of a cast iron pedestal surmounted by a cast iron casing with a dished bottom and outlet lip, the top being fitted with a cover having a funnel in the centre for the purpose of feeding the machine. Inside this casing a basket or perforated drum revolves, being actuated by a vertical shaft whose bearings are in the neck and foot of the pedestal. The basket is not compelled to revolve about a fixed centre as in other machines, but is permitted to find its proper centre of rotation by the use of elastic bearings, thus reducing the power required to drive the machine to a minimum, as also the amount of vibration transmitted to the casing of the machine. The vertical shaft is driven at the rate of three thousand revolutions per minute by means of a rope drive from a small countershaft carried by swing bush bearings mounted on a cast iron frame. The shaft is also fitted with fast and loose pulleys for belt driving. The lubrication of the swing bush bearings of the countershaft, as well as in the bearings in the machine proper, are most efficient, the former being self-oiling and the latter being fed from an oil cup and tube outside of the casing and pedestal. The machine is fitted with a suitable foot brake to enable the operator to stop the process at any moment. The machine was thoroughly tested by passing latex which had been freely and well mixed with sand, lumps of earth, chips, twigs, bark, etc., through the funnel in the top lid of the outer casing and into the centre of the revolving basket or perforated drum.

Inside the latter is placed a linen or cloth bag, and it is through this that the latex is rapidly strained leaving the lighter and large impurities behind it. The strained latex then passes into the outer casing and finally issues from the pipe at the side into a receptacle below. By this means large quantities of latex can be strained in a very short time.

"The machine takes about 1 H. P. to drive, and its output is 50 gallons per hour."

The writer was informed, when at Culloden in April, 1908, that the machine, though useful, had not been much used by Mr. Macadam—or any other planters in Ceylon.

"The machine shown by Mr. Kelway Bamber is much the same as that exhibited by Mr. Macadam, except that no cloth bag is used and that the bottom and the periphery of the drum are solid, and the top also is partly closed.

"The latex is poured into a funnel in the lid in the same manner as that described in the other machine, except that it has to be very carefully and slowly fed into the centre of the revolving drum. The heavier particles of the impurities in the latex are thrown centrifugally against the periphery and are there collected and retained, being helped somewhat by means of short partitions, whilst the pure latex rises over the top of the drum into the outer casings and then finally issues from a pipe into a receptacle below. The output of the machine is roughly estimated at 20 gallons per hour." Having secured latex free from any mechanical impurities the first step towards the production of crude rubber is coagulation.

PHENOMENON OF COAGULATION.

The physical and chemical changes involved in the phases of coagulation already recognised are numerous and complex, and many theories have been put forward to explain the phenomenon. It may be argued that the practical planter does not need to trouble himself about the changes which lead to the separation of the rubber from the latex, since this is accomplished by simply allowing the latex to stand in a receptacle, in the open. The writer is of the opinion, however, that the methods adopted on Eastern estates still leave much to be desired and if a better knowledge of the changes incurred, during coagulation, can be gained, planters of an inventive frame of mind will quickly effect improvements; for these reasons it is proposed to study the phenomenon of coagulation in some detail, and to consider latices from species other than *Hevea brasiliensis*.

The latices from different species possess varying quantities of resins, proteins, caoutchouc and inorganic substances, but the behaviour of these to the same agencies—heat, moisture, centrifugal force, preservatives, acids, and alkalies—is widely different: the phases of coagulation of latices from distinct botanical sources require

separate and detailed investigation. Heat, though it coagulates many latices, has no such effect on that of *Hevea brasiliensis*; formaldehyde though acting as an anti-coagulant with *Hevea* latex appears to coagulate other latices; alkalies which help to maintain some latices in a liquid condition hasten the coagulation of others; mechanical means while allowing one to effectively separate large-sized caoutchouc globules from some latices are almost useless when dealing with the latex of *Hevea brasiliensis*.

THE THEORY OF COAGULATION.

The changes which take place during coagulation have been variously explained, some authorities contend that heat alone softens the caoutchouc globules and thus allows them to unite; others maintain that a film of protein matter around each caoutchouc globule becomes coagulated and encloses the rubber particles which then form an agglutinated mass: many believe that coagulation can be easily effected in the absence of any protein substances. The term "coagulation" was, according to Spence, originally applied to the coagulation of the protein, but it is now generally used to denote the separation of the caoutchouc globules and all those processes which lead to the production of a mass of rubber from latex. When some latices are allowed to stand, the caoutchouc globules readily agglutinate, when they rise to the surface; the cream thus secured is then coagulated by pressure. When the latex of *Hevea brasiliensis* is treated with dilute acetic acid the caoutchouc does not cream and then coagulate; the latex, according to Bamber, coagulates throughout its mass, thus including much protein and suspended matter, and by its own elastic force then contracts towards the surface of the liquid, expressing a clear watery fluid still containing protein matter in solution.

Henri,* who carried out a series of experiments with the latex of *Hevea brasiliensis*, pointed out that in connection with the coagulation of latex there exists a series of bodies which readily cause coagulation in some, but have no effect on others; he also remarks that the coagulation of latex has been compared with that of albuminoids, it even being surmised that these substances are essential to the process. He maintains, however,† "that the latex is a suspension of very fine particles in aqueous liquid more or less rich in saline or organic bodies. When coagulation occurs the rubber globules unite."

PHASES OF COAGULATION.

As the result of his experiments with dialysed latex Henri concluded that "On adding different reagents to the latex one of three things may occur:—

1. There is no reaction.

* *Le Caoutchouc et la Gutta Percha*, May 15th, 1907.

† *India-Rubber Journal*, August 12th, 1907.

2. Isolated flakes, varying in size, are formed which either rise or sink, but do not unite, being readily separated by stirring. This may be termed the agglutination of the latex.

3. A network of long threads encircling all the globules of the latex is observed. On stirring, the threads reunite, forming a solid elastic coagulum. This is the true coagulation of the latex."

EFFECT OF REAGENTS ON LATEX.

Henri determined the effect of a large number of reagents on the dialysed latex, both individually and mixed, with the following results—

"Methyl, ethyl and amyl alcohol produced no reaction. Hitherto alcohol has been considered a coagulant, but its action evidently is due to salts present in the latex. Sodium, potassium, and ammonium salts also have no effect. Salts of calcium, barium and magnesium in sufficient quantities cause agglutination. Hydrochloric, nitric and acetic acids all cause agglutination; very dilute sulphuric acid also has the same effect, but if more concentrated coagulation commences. Trichloroacetic acid even when very dilute, produces a remarkably elastic coagulum. Acetone also is a coagulant."

"Regarding the action of mixtures, as a rule alcohol added after a salt produces agglutination or coagulation. On studying the influence of alkalis on the coagulation of the latex it was found that an extremely small quantity interfered with the reaction; a tenthousandth normal solution was sufficient to prevent agglutination or transform coagulation into agglutination. Thus magnesium chloride and alcohol produce coagulation, but if the latex is rendered even very slightly alkaline, only isolated flakes are formed, again showing that the passage from agglutination to coagulation is gradual, and that one may be considered as a higher stage of the other."

The foregoing are very long extracts from V. Henri's work but in view of the importance of his observations, and especially those showing that the final strength of rubber may be largely determined by the nature of the coagulant used—a point confirmed by Spence and others—full publicity is given to the results obtained.

STRUCTURE OF CRUDE RUBBER.

Dr. J. Torrey, in his contribution * entitled "Note on the Physical Structure of Crude Rubber" points out that Henri gives a series of plates showing the structure of the rubber obtained by coagulation of the latex with different reagents, and shows that the same latex yields products of totally different character (as to length of fibre, elasticity and life) according to

* India-Rubber Journal, November, 1907.

the reagent by which it is coagulated. Sometimes the rubber separates in the form of fine flecks which show little or no tendency to unite with other coagulants, the flecks either unite to form larger flecks, or one obtains at once a deposit which from the first has a lace-like structure. In these latter cases the product is very elastic; in the first case it is notably less so.

Some years ago Torrey observed that "petroleum naphtha solutions of a number of crude unwashed rubbers gave characteristic figures when a few drops were allowed to evaporate on a white surface. The solutions consisted of 5 grams of each rubber in 100 cc., petroleum naphtha boiling at 60 deg. to 90 deg. C. I recall that Fine Para and Matto Grosso were the two South American grades; and among the Africans were Laporì, Red Kassai, Upper Congo Ball, Ikelemba and Bussira."

"Fine Para gave always a fine regular lace-like pattern; Matto Grosso gave a very similar one, but not so fine and not so regular. Some of the African gave the same general type of figure, but much coarser. Others deposited the rubber in the form of one or two nebulous spots, shading away very gradually toward the edges, and connected by a few rather faint filaments which were usually disposed between the two spots in the form of a single mesh of a coarse network—the mesh being approximately circular in form. The most characteristic case of this kind was Laporì. On the whole, the difference between the figures corresponding to different rubbers was so great that even an untrained observer could, without difficulty, identify almost any one of the varieties under examination by its figure."

PROTEINS AND COAGULATION.

Dunstan* has pointed out that the original view taken of the process of coagulation—to the effect that it was dependent upon protein coagulation and the separated proteins carrying the rubber globules with them—cannot be now accepted. Dunstan states that "There are peculiarities connected with the coagulation of latex which are opposed to the view that it is wholly explained by the coagulation of the associated proteins. Experiments made with latex from India, led them to the conclusion that 'coagulation' can take place after removal of the proteins, and that in all probability it is the result of the polymerisation of a liquid which is held in suspension in the latex and on polymerisation changes into the solid colloid which we know as caoutchouc. There is little room for doubt, that the coagulation is due to the 'condensation' or polymerisation of a liquid contained in the latex. What is the nature of this liquid from which caoutchouc is formed?"

* Some Imperial Aspects of Applied Chemistry; Bull. Imp. Inst.: Vol. IV, No 4, 1906.

PROTEINS AND FUNTUMIA LATEX.

Spence* carried out experiments with the object of determining the effect of digesting the latex under suitable conditions with various ferments; rennet, trypsin, and pepsin were used "in the hope that by decomposing the proteins or such like bodies into simple derivatives coagulation may be effected." Negative results only were, however, obtained. Spence concluded from the results of his work with *Funtumia elastica* latex "that there are present in the latex nitrogenous substances capable of digestion by trypsin into simpler complexes, without at the same time bringing about coagulation of the caoutchouc, so that further experimental evidence is still required before these protein-like bodies, as Weber suggested, can be regarded as the all-important factor in connection with latex coagulation. The evidence brought forward by him for the existence of a film of protein surrounding each caoutchouc globule is too incomplete, and unless the protein forming this film is of quite a different nature from that which is acted on by the ferment in the above experiments, it is difficult to conceive how the destruction of this film should not result in the immediate polymerisation of the liquid contents of each globule with the formation of a solid coagulum of caoutchouc. The action of trypsin and pepsin on latex must be further investigated, however, before far-reaching conclusions in regard to the condition of the protein-matter in latex can be drawn. The present results are suggestive, however, and in view of the recent work of Victor Henri on the coagulation of latex, I am now inclined to believe that the condition of the caoutchouc globule in the latex in general is maintained, not as Weber supposed by the presence of a protein sheath (although it may be possible that the physical state of the caoutchouc particles is not the same in all latices), but in virtue of the negative electric charge on the colloid aggregate opposing the surface tension of the particles. When agglutination (and coagulation) is produced by any means it is due to the disturbance of the equilibrium between these forces, and not to the presence of a film of protein matter which, becoming coagulated, brings down the caoutchouc with it." Having touched upon the general changes associated with the processes of agglutination and coagulation we can proceed to consider the purely practical methods adopted in rubber-growing areas.

NATURAL COAGULATION.

If latex is allowed to stand exposed to air coagulation takes place after an interval of from 6 to 24 hours. The coagulated substance carries, or becomes mixed with, the suspended globules of caoutchouc and other bodies, so that the whole process is more or less one of clarification, the liquid left behind usually

* India-Rubber Journal, September 1907.

containing only those ingredients of the latex which have remained in solution. Coagulation occurs as soon as the latex becomes neutral or faintly acid, no matter what proportion of suspended globules of caoutchouc or other constituents may be present in the latex.

Burgess states that the natural method of coagulation is *only possible where a washing machine is used*, and suggests that where the latter is in use the latex might be allowed to stand for 24 or 36 hours, and the natural fermentation allowed to take place and produce coagulation. It is difficult to understand this contention, if by a washing machine is meant one similar to that recommended by the same authority for the manufacture of crêpe rubber in Malaya—indeed, if it were so it would constitute a serious disadvantage to the method of coagulation by natural means. As a matter of fact, biscuit and sheet rubber can be prepared by the natural and artificial methods with equal ease, without the use of any machinery beyond an ordinary mangle and a blocking apparatus.

On estates where the daily quantity of latex is small the use of chemicals and machinery for rapidly coagulating it is not always necessary; the latex is put in shallow pans and allowed to set. The biscuits or sheets, when ready, are rolled to squeeze the water out and then placed on wire gauze, wooden, or coir shelves to dry. A strong current of dry air might be obtained by drawing the air by means of a fan through a chamber containing chemicals such as freshly-burnt lime or calcium chloride, which would absorb the water. It should not be difficult to arrange a building on a plan somewhat similar to the tea-drying and cacao-curing rooms in common use in Ceylon: in fact many such buildings are used for drying the rubber on well-known estates in that island.

ARTIFICIAL METHODS OF COAGULATION.

Some kinds of latex can be heated for a long time—almost indefinitely—without coagulation being effected, whereas other kinds coagulate rapidly on the application of heat.

According to Parkin the diluted latex of Para rubber is unaffected by boiling. If the undiluted latex is boiled, water is driven off, and the thickened milk may then become charred. The separation of the caoutchouc of *Castilloa*, *Ficus* and *Landolphia* latices is often effected by boiling on a slow fire.

The addition of certain chemical reagents to the heated latex brings about coagulation; dilute mineral acids, acetic acid, and tannic acid are particularly active.

There are numerous mechanical and chemical processes by means of which rubber can be obtained from latex.

Until the various theories outlined elsewhere have been definitely proved and accepted, we can best regard—in a work such as this which is written for the guidance of the practical



Photo by C. H. Kerr.
LATEX IN SETTING OR COAGULATING PANS.

planter—some of the protein substances as playing an important part in coagulation. Certain proteins remain in solution even after coagulation; others are capable of being converted into an insoluble form and occur in all rubbers.

SPONTANEOUS COAGULATION.

In some countries the latex is allowed to coagulate along the tapping lines, exposure to air being the only desideratum: a large part of the latex from *Hevea brasiliensis* is thus coagulated. The latex from *Landolphia* vines, *Manihot* and *Sapium* trees, is never collected in the liquid state but is often spontaneously converted into rubber on exposure to air.

NATURAL HEAT

Explorers who have visited American and African rubber-producing areas report that the natives frequently collect the latex and rub it over their arms and chests and allow the heat of the body and the feebly acid perspiration to aid in the production of rubber. The thin particles thus obtained are gathered and made up into balls for export.

ADDITION OF WATER.

The addition of pure water to the latex of *Hevea brasiliensis* does not hasten coagulation but, as in the case of many other latices where the caoutchouc globules are very small and light, delays the formation of a solid clot for a considerable time. It is worthy of note, however, that the caoutchouc of *Castilloa* is sometimes agglutinated by the addition of water, and one report states that the same result is sometimes obtained when the latex of *Funtumia elastica* is similarly treated: the caoutchouc in both these latices can be creamed or separated by means of a centrifugal machine.

ADDITION OF PLANT JUICES.

Organic or mineral acids bring about the coagulation of the latex of *Hevea brasiliensis*. In parts of Ceylon some very interesting results have been obtained by the use of clear aqueous solutions of citrus, tamarind, and other commonly-occurring acid fruits. Samples of perfectly dry plantation rubber, obtained by adding plant juices to the latex, have possessed remarkable strength and may yet be associated with the principles outlined by Henri. In parts of tropical America and Africa these reagents are largely used and many believe that the strength of the coagulated rubber is much improved thereby.

The plants used in different countries differ considerably in their botanical relationships, but the watery extracts from most of them, now in use, have an acid reaction. There are a few which are said to have an alkaline reaction.

According to Jumelle, the natives in French Soudan use four liquids for coagulating *Landolphia Heudelotii*, A. DC.; (1) juice of citron, made by crushing ten fruits, to a litre of water; (2) water acidulated with the fruit of *Adansonia digitata*, L., one ripe, macerated fruit being sufficient for one litre of water; (3) water acidulated by the leaves or calyces of the Rozelle plant - *Hibiscus Sabdariffa*, Lin.—500 grams of leaves and fruits being used in one litre of water; (4) infusion of fruits of *Tamarindus indica*, L., 2 handfuls of fruits being required for one litre of water. All these plants are abundantly distributed and cultivated in many parts of the tropics and can easily be tried by planters. In Ecuador and the Belgian Congo, the juice from the stalks of "bossanga"—*Costus Lukanusianus*, K. Sch.,—is largely used as a coagulant. The watery extract from the macerated stalks of *Calonyction speciosum*, Choisy,—which, according to Preuss is alkaline in reaction—is also used in Ecuador and Central America generally. Another plant which has received considerable attention as a source of an effective coagulant is *Bauhinia reticulata*, a species now established in most of the Botanic gardens throughout the tropical world. It is largely used in the production of rubber from the latex of *Funtumia elastica*. According to Mountmorres* a handful of the green leaves and the young shoots is placed in two gallons of water, and boiled for about fifteen minutes, the filtered infusion being poured, while hot, into about one and a half gallons of fresh latex.

It is obvious that aqueous extracts of parts of plants such as those mentioned above may contain a number of useless as well as useful ingredients; it is therefore difficult to ascribe the good physical properties of the coagulated rubber to any definite substance or substances until the points have been chemically investigated. The plants used for this purpose are among those most commonly met with in tropical areas, and the subject is therefore one which should arrest the attention of all rubber planters.

SMOKING AND COAGULATION.

The coagulation of the latex may be hastened by exposing it to heat and the products of combustion of a fire. The latex can be coagulated fractionally by such a process, and the finished product, when properly manufactured, is less liable to putrefaction than the rubber prepared by many other methods. The smoke from burning palm nuts used in the Amazon district contains, among other substances, small quantities of acetic acid, acetone, and creosote. The acetic acid is probably the agent responsible for effecting coagulation; the other substances, particularly the creosote, are absorbed, the lat-

* Viscount Mountmorres. Quarterly Journal of the Liverpool University, 1907.

ter acting as an antiseptic in preventing the rapid decomposition of the albuminoids present.

THE AMAZON METHOD.

In Brazil the latex is poured into a shallow basin, 60 cm. to 1 metre in diameter and 20 to 30 cm. deep, and pieces of bark, dirt, &c., removed. A fire is then made of wood and resinous substances, and is kept going either with green branches of *Mimusops elata*, All., or with palm nuts from *Attalea excelsa*, Mart., and *Maximiliana regia*, Mart; these palms are usually grown in Botanic Gardens in various parts of the Tropics, the latter species being more commonly known as the "Cocurito" palm. A chatty, open at both ends, is placed on the fire and the smoke allowed to issue from the upper aperture.

A paddle-like implement is then dipped into or covered with the latex, and held over the smoke until the latter is coagulated. It is stated by Bonnechaux* that 8 litres of latex are completely coagulated in about 1½ hour by these means. The same principle is said to be adopted in parts of the Congo, in the preparation of Landolphia rubber. The decomposition of the albuminous substances in the rubber may be prevented by the addition of suitable antiseptic reagents to the latex, when the rubber is prepared in other ways, though quickness in drying or complete extraction of the moisture from coagulated rubber is often sufficient to bring about the same result.

PATENT SMOKING PROCESSES.

G. van den Kerckhove has patented an apparatus called the "Fumero" designed for use on plantations where the smoking of rubber is desired.

The "Fumero" is about 80 centimetres in height, can be transported by hand from one place to another, and when lighted emits smoke containing creosote. The inventor states that coagulation is effected without the addition of acid and the rubber can be made up, finally, in the form of sheets, biscuits, balls, etc. It was explained by the writer at the Ceylon Rubber Exhibition that hot smoke, from smouldering logs of wood which had been previously steeped in creosote, brought about coagulation of the latex through which it was passed.

BROWN AND DAVIDSON'S PROCESS.

Another method was, at the time of the Ceylon Rubber Exhibition, brought forward by Messrs Brown and Davidson. They exhibited an apparatus which was described as follows by Mr. G. H. M. Hyde in the Official Account of the Exhibition:—"The

* Jumelle, l. c.

apparatus consists of a fireplace in which wood soaked in creosote is allowed to smoulder; from thence the smoke passes along a flue or pipe connected to the bottom of a sheet iron annular column about 6 feet in height and from 3 to 4 feet in diameter. The inner column is a closed sheet iron cylinder finished off at the head in a conical form and surmounted with a funnel; on the other hand, the outer casing is made in two halves hinged together like doors. The whole height of the annular column, that is, the space between the two cylinders, is baffled by means of a series of circumferential plates or rings inclined downwards. These plates are rivetted to each of the cylinders alternately, thus forming a complete series of baffle plates. The head of the annular space is fitted with sliding doors which are easily adjusted in order to allow for the egress of smoke or admission of air."

"The working of the machine is thus: the fresh latex is poured through the sieve into the funnel at the top of the inner column, the flow being distributed over the whole of the circumference of the inner cylinder by means of small channel ways; from thence it slowly flows over or drips from each baffle plate in turn, *i. e.* down through the whole height of the annular column, thus exposing a large surface for impregnation with the creosote-laden smoke with which the whole annular space is filled from the adjacent slow combustion fireplace. The smoked latex is collected in the dished bottom of the annular space, and finally issues from a pipe into a receptacle below, to be put through the machine again should it require further treatment." During working operations it was necessary to cool the smoke before its arrival at the latex cylinder and even then the hot fumes from the smouldering latex appeared to coagulate some of the latex along the baffle plates. This apparatus, though capable of doing good work, does not appear to have been improved since the Exhibition and it is doubtful whether many such machines are, at present, in use.

MACADAM'S PROCESS

An apparatus brought forward by Mr. C. O. Macadam of Cul-loden is designed to impregnate the latex with creosote smoke and to effect coagulation. According to Zacharias "It consists of a series of metal planes, slightly inclined and placed zigzag fashion one below the other. The latex is poured in at the top and has to flow over all these planes, being caught at the bottom in a pail. The whole is enclosed in a box with an aperture to admit the smoke, which thus completely fills the interior and thoroughly impregnates the latex. The latter being poured in again and again, films of coagulated rubber very soon begin to form on the plates; these increase in thickness, and eventually form smoke-cured sheets, which only require drying to be ready for the market."

WICKHAM'S SMOKING PROCESS.

Mr. H. A. Wickham has patented what may yet be an important adjunct to estate factories. The machine in question provides a rotating or travelling device adapted to carry the rubber latex and to expose successive thin layers of it for treatment by smoke or other agents. A means of directing the smoke or other agent is also provided.

It is to be observed that by means of this apparatus the cured product is delivered in the form of a hollow cylindrical ring

In this apparatus dense smoke is produced in the furnace, this being effected by burning the oily nuts of palms with charcoal. The liquid latex is poured into the lower portion of a cylinder and the cylinder is then rotated. As the cylinder rotates, the bulk of the latex will remain in the lower segment, but a thin film will adhere to the inner surface of the cylinder and be carried round with it and exposed to the smoke which cures and coagulates the india-rubber, forming a skin of solidified rubber on the inner surface of the cylinder. During the next rotation a fresh film of latex is carried round on the surface of the first skin and in its turn cured and coagulated, and this may be continued till a ring of rubber of considerable thickness is formed which can be pulled out of the cylinder. The setting of the rubber films should be observed through the opening in the side of the cylinder, and the speed of rotation regulated accordingly. By this means the whole of the latex treated is exposed in successive thin films to the action of the smoke and a well-cured and homogeneous rubber is obtained

The point at which the smoke is first delivered upon the rubber is preferably situated sufficiently above the level of the main body of latex in the cylinder to enable each fresh film to form evenly before it arrives in front of the smoke jet.

As already pointed out other suitable treating agents may be used in place of the smoke.

The writer saw one machine in working order in London and was of the opinion that some modification would be necessary on the estate. A complete plant was sent to an estate in Malacca and the results are awaited with interest.

In all these processes the main object is to add a preservative to the latex or freshly coagulated rubber so that decomposition will be retarded. The simplest way to effect this is obviously to add to the latex an alcoholic solution of creosote and mix the liquids well together. If anything further is required the outer surface can be smoked by placing the coagulated or pressed rubber in a building charged with smoke. To effectively treat the latex with antiseptics or to smoke the rubber in its initial and final stages should not be very difficult.

DA COSTA'S SMOKING AND COAGULATING PLANT.

A new process for coagulating latex and mechanically incorporating the particles of rubber with creosote has recently been brought forward. In this method the latex, when brought from the field, is strained to remove mechanical impurities, and is then poured into the coagulating tanks. Steam is meanwhile being raised to about 30 to 35 lb. per square inch in the boiler, forest woods alone being used for this purpose.

On the burning wood in the boiler furnace green Palm leaves, nuts, or any green twigs of tropical trees are thrown, small quantities of acetic acid and creosote being thereby obtained. The fumes are accumulated in a special receptacle and forced into the coagulating tanks by a steam injector

The force of the steam violently agitates the latex and during this operation every particle of it is said to be reached by the smoke. In a short time the whole mass coagulates and the floating rubber can then be removed.

The inventor proposes to allow the coagulated rubber to cool off in the tanks, and afterwards have the masses pressed and blocked; the blocks to be subsequently reblocked in cube form and afterwards dried either in a special stove or vacuum dryer.

It is claimed that this smoking and coagulating plant allows the planter to dispense with chemical re-agents in a liquid form and ensures that rubber of all kinds shall be sent to the market in a satisfactory condition. The apparatus has been made by Messrs David Bridge & Co., England.

Samples of rubber prepared by this method have been reported upon favourably by a rubber manufacturer.

COAGULATION BY CHEMICAL REAGENTS.

In coagulation by such means the object is to use reagents which, while effectively and rapidly precipitating the coagulable material, will not have a detrimental effect on the rubber produced.

Many compounds, such as picric acid, would rapidly induce coagulation, but the effect on the resulting rubber would be bad. Weber and Parkin have shown that many acids may be used in the coagulating process, but it is unnecessary to do more than mention those which have, from practical experience, been proved more or less acceptable to producers in the Tropics and manufacturers in Europe.

Acetic acid.—This is cheap, always procurable, is not dangerous to handle, and is as effective as formic acid. It is not as powerful as tannic acid, though it is effective in bringing about the coagulation of the latex while cold. The commercial article varies in strength

and the quality should be noted by the purchaser. The rubber produced by means of this coagulant, is, according to Henri, of inferior quality.

Formic acid.—This, though similar to acetic acid in its effect, is more expensive, weight for weight. The advantages of using this reagent are (1), that less is required than acetic acid, and (2) it has antiseptic properties. Whether acetic or formic acid is used, it should be applied in definite proportions, and no more need be used than is required to just precipitate the albumen in the latex. The same may be said of hydrofluoric acid.

Tannic acid.—This is, according to Weber, the most powerful of the acids which can be used for this process; he asserts that on a laboratory scale it is excellent for use with the latex of Para rubber. If rubber coagulated by tannic acid, while still wet, be placed in an incubator at temperatures from 100° F. upwards, it rapidly passes into a state of putrescent fermentation, but such a change does not occur if the rubber is thoroughly dry.

Mercuric chloride.—Corrosive sublimate effects coagulation while the latex is cold, and also acts as an antiseptic. It is very poisonous, and if used a small quantity of mercury is unavoidably left in the rubber.

Mixtures.—The following mixture produced a sample of rubber of excellent quality at the Ceylon Rubber Exhibition in September last:—

1. 1 dram of Cream of Tartar, dissolved in 1 oz. cold water, added to a pan full of latex of about 48 oz.
2. 1½ dram Cream of Tartar, dissolved in 4 oz. of fresh rubber when added to a pan full of latex of about 48 oz.

Mr. J. A. Bird is said to have originated the idea.

Mr. H. Hesketh Bell, in giving an account of his observations in Uganda stated that carbonate of potash is usually added to the filtered latex, but the objects in view are not clearly defined.

AMOUNT OF ACETIC ACID TO BE USED.

The quantity of acid required is believed to largely depend upon the proportion and condition of the albumen in the latex. According to Weber the latex of Para rubber in its native habitat contains only about 1·5 per cent. of albumen, and one-third of an ounce of anhydrous formic or half an ounce of glacial acetic acid per gallon of the latex is quite sufficient to produce a rapid and complete coagulation. The behaviour of the latex from Para rubber trees with acids is due to the fact that the milk is, when fresh, usually slightly alkaline or neutral, and the protein substances are insoluble in a feebly acid solution but soluble in alkaline or strongly acid solutions. It has been

asserted that the protein matter is insoluble in a neutral solution, but on several occasions the fresh latex from the Henaratgoda trees remained liquid, though the reaction with litmus paper did not indicate acidity or alkalinity. Only a small quantity of acid is required to neutralize or acidify the latex, and therefore lead to the precipitation of the proteins. It is a mistake to add excess of acetic acid, as the proteins or their derivatives would be partly re-dissolved and, therefore, still remain in solution.

The amount of pure acetic acid necessary for complete coagulation depends upon the quantity of proteins to be precipitated; the latex in Ceylon, according to the analyses already quoted, contains from 2.3 to 2.8 per cent. of these substances. If ordinary latex is allowed to stand for some time, the protein matter decomposes and acidity sufficient to lead to coagulation is developed. Diluting the latex will not reduce the total quantity of acid required. Every 100 volumes of pure Ceylon latex require approximately one volume of pure acetic acid. Many planters add one or two drops of acetic acid to about half a gallon of the diluted latex. On Culloden estate three drams of acetic acid are added to each gallon of latex no matter in what condition the latter arrives at the factory; the acetic acid consists of three parts water and one part glacial acetic. On Gikiyanakanda one dram of acetic acid is used for each gallon of latex. If the acetic acid is added until the mixture becomes neutral after stirring—*i.e.*, will neither turn litmus paper red nor blue, or until it is feebly acid—very little harm will be done. The addition of excess of acid may bring about a re-solution of the proteins and coagulation be thereby delayed. It is very rare that the latex on a large scale is heated before treatment with acetic acid.

TIME REQUIRED FOR COAGULATION.

The completeness of the precipitation is judged by the clearness or turbidity of the liquid in which the rubber floats. When the separation of caoutchouc is complete, the mother liquor is quite clear; where special machines are used the latex is coagulated in three to ten minutes. On Culloden estate, without the use of any apparatus the latex is completely coagulated in ten minutes on Vogan in a couple of hours; and on another estate in the same district half an hour was generally allowed for complete coagulation.

METHOD OF DETERMINING THE AMOUNT OF ACETIC ACID REQUIRED.

It has been contended that many inventions which have recently been brought forward necessitate dilution, to varying degrees, with water, ammonia, and formalin, and that such dilution prevents the planter from knowing how much latex the coolies collect, and how much acetic acid will be required in the process of coagulation. It is quite true that the latex so treated will contain varying quantities of rubber, but when one considers the variation in composition

of ordinary samples of undiluted latex from different trees, or when obtained at different times of the year from the same trees, it is obvious that the same difficulty has ordinarily to be overcome; the objection is, therefore, not a very serious one so long as latex is not sold by volume.

The application of the same quantity of acetic acid to the same *volume* of latex cannot be recommended except for expediency. The acid should be added in order to neutralize or faintly acidify the latex; it is better to determine the exact quantity required rather than add too much.

The amount of acid required can be determined with ease. Let the coolies pour the diluted latex from the different trees into a settling tank or ordinary receptacle and fill up to a known level, so that the exact volume will be known. After thoroughly stirring the mixture take a small sample of known volume and add dilute acetic acid of constant strength, drop by drop, from a burette or graduated glass tube, until the whole mixture after stirring is neutral or faintly acid. On measuring the volume of acetic acid used, the amount required for complete coagulation of the latex in the settling tank can be easily calculated and added. Litmus paper can be used to determine when sufficient acetic acid has been used; the resultant solution should be only faintly acid or neutral, blue litmus paper becoming faintly red and red litmus paper remaining unchanged respectively in such solutions.

Such a method involves the accumulation of the latex in receptacles of known capacity and provided with mechanical means for keeping the latex in a liquid state. Some such apparatus may or may not be required as the trees on the various rubber estates are more frequently tapped.

ADVANTAGES AND DISADVANTAGES OF ADDING CHEMICALS TO THE LATEX.

It has been frequently contended that the home manufacturers object to the use of chemicals in the coagulation of the latex, particularly mineral and vegetable acids, on account of the fact that even after thorough washing and pressing some of the acid may still remain in the rubber and subsequently prove harmful in the manufacturing processes. The retention of a large proportion of foreign chemical ingredients is said to lead to the production of bubbles and blow holes and to be occasionally accompanied by early deterioration of the prepared rubber.

On the other hand, it can be shown that the addition of reagents such as formalin, corrosive sublimate, creosote, or acids such as formic and even hydrofluoric, have a preservative effect on the rubber when used in infinitely small quantities. When one considers the chemicals which are incorporated in rubber of good repute prepared

by the natives in the Amazon district and the inert characteristic of rubber itself, the objection to the use of minimum quantities of reagents such as acetic acid and creosote seems to be less tenable. But apart from the preservative action of some of the chemicals used, there is a much more serious advantage, to the producer, accompanying the use of the required quantity of acetic acid, viz., the rapidity and completeness of the coagulation effected.

In one experiment about $1\frac{1}{2}$ gallon of ordinary latex was poured into a large glass beaker and allowed to coagulate naturally. At the end of two days a large cake of rubber had formed at the top of the liquid, but the mother liquor was still quite milky; the cake of rubber was removed, and subsequently thinner cakes appeared at the surface and were removed; after six days the mother liquor still remained turbid, and a further quantity of rubber was prepared from it by treatment with a small quantity of acetic acid and heating. The completeness of coagulation, when the latex is allowed to set untreated with acids, does not always take such a long time, but it is probable that the same phenomenon may repeat itself, and thus necessitate considerable delay and perhaps waste; certainly it would involve considerable irregularity to the producer. The use of acetic acid, on the other hand, effects coagulation in a few hours, and the mother liquor becomes perfectly clear in less than a day; the precipitation is complete, and there is therefore no waste of rubber.

If the planter is compelled to stop using acetic acid for assisting coagulation, and has to produce his rubber by simply allowing the latex to slowly ferment, there are other difficulties in the way. It is obviously to the advantage of the producer to reduce the proportion of scrap in his rubber and to keep the latex flowing as long as possible, and the use of ammonia and formalin to accomplish this is being adopted on many estates during tapping operations; the presence of these reagents in the latex tends to prevent coagulation, and they would, therefore, further aggravate the question of delay necessary if the natural process of coagulation were compulsory; a longer period of time would be required for the necessary acidity to develop in presence of either of these reagents.

In the absence of definite information from home manufacturers, the use of minimum quantities of acetic acid, determined by the simple method previously described, is likely to be continued by the producer in the Tropics; it is a constant factor in the preparation of fine Para rubber in Brazil. It will be necessary to prove that the effect of the use of acetic acid is really bad before the producer will risk the possible loss in yield suggested by the frequent turbidity of the mother liquor, and the uncertainty or delay incurred in the production of rubber from latex by the natural process.

For the present the application of the correct quantity of plant juices or acid, followed by thorough washing and rolling, may be

adopted, but care must be exercised not to add excess, and every effort be made to subsequently expel the reagent by suitable mechanical processes.

INFLUENCE OF COAGULANT ON STRENGTH OF RUBBER.

The observations of Henri regarding the influence of the various coagulants on the strength of the rubber are extremely important to planters. If the reagents which are now so largely used on Eastern estates produce an inferior rubber others should be taken up. Henri claims to have proved that "the structure of the coagulum varies with the nature, and concentration of the substances employed for coagulation. A weak coagulant produces a pulverulent or flaky precipitate; a strong coagulant, on the contrary leads to the formation of an elastic curd with reticular structure. When the structure of the reticular curd obtained by different coagulating agents is considered it is seen that the smallness of the meshes varies with the coagulant and speed of coagulation. The elastic properties of rubber obtained by coagulation of the same latex vary much with the different coagulants employed."

The curds which Henri obtained by coagulation of latex were rolled out in sheets, dried, cut into strips and mechanically tested. The following were his results. (The last column gives elongations at moment of rupture):—

Mode of Coagulation.	Rupture Stress per millimetre.	Elongations.
Heat 80 deg. C.	150 g.	8.5
Heat 25 deg. C.	190	7.2
Weak acetic acid	175	7.5
Strong acetic acid	210	7.1
Tri-chloroacetic acid	325	6.8
Acid + electrolyte 1	310	6.8
Acid + electrolyte 2	380	6.8
Acid + electrolyte 3	660	6.5

"The elastic properties of rubber are therefore considered to be in relation with the fineness of the reticular structure of the curd, and the latter depends upon the coagulant employed." Thus with the same latex Henri showed that rubbers with different values can be obtained, a most important determination to all rubber planters.

Henri's observation—that the fineness of the reticular structure depends on the nature of the coagulant and the rate of coagulation—has been confirmed by Dr. Spence,* who now states that the elastic properties of rubber may vary with the coagulant employed. This is a point which should be well studied by all planters who are anxious to improve the physical properties of

* *Funtumia elastica*, by Dr. Spence, *India-Rubber Journal*, August, 1907.

their rubber; if the acetic acid so largely used on Eastern Estates produces an inferior rubber its use should be discontinued and the latest results of science given a practical trial on a large scale. There is no time to be wasted in this direction, especially on plantations where all the trees are young. Dr. Spence is of the opinion, from his analyses of *Funtumia elastica* latex and rubber, that if the nitrogenous compounds in latex could be broken up in a particular manner the quality of the final rubber might be considerably improved. Is this also likely with *Hevea* latex?

COAGULANT AND STRENGTH OF VULCANIZED RUBBER.

Messrs Clayton Beadle and Stevens (Chemical News, November 22nd., 1907), state that though the method of coagulation may affect the physical properties (nerve) of raw rubber, the difference in reticulation recorded by Henri may have no effect on the properties of the ultimate vulcanized product. At the temperature of vulcanization they maintain that all traces of structure disappear, even if it has not already been obliterated during the process of mastication. They should not lose sight of the fact, however, that raw rubber is sold by producers on its physical properties alone. Too much stress cannot be laid on the importance of preparing plantation rubber in such a manner that its nerve shall, if possible, be equal to that of fine hard Para.

The same authors, in the same contribution, point out that there is most striking proof of the influence of the conditions under which crude rubber is prepared on its physical properties in the "apparent" specific gravity of the rubbers examined by them. The specific gravity of one biscuit was low corresponding with a low tensile strength. That of a block was lower still owing to the presence of a large number of air bubbles. Heating a block reduced its tensile strength; freezing a block for one week improved the tensile strength without materially affecting the specific gravity.

COMPONENTS OF COAGULATED RUBBER.

Whenever the rubber is prepared by ordinary coagulation, either by the smoking method or the use of familiar chemical reagents, hot or cold, it is obvious that the rubber must contain the precipitated proteins together with the suspended globules of caoutchouc, resin, &c. Analyses of well-dried Para rubber show only a small percentage of substances other than caoutchouc—practically from 4 to 5 per cent.—and it may at first sight appear unnecessary to draw attention to the desirability of extracting them. If one compares the analyses of latex and rubber from *Hevea brasiliensis*, it is surprising to find that when chemical reagents have been used the percentage of protein matter in the rubber shows that the whole of that in the latex was not precipitated, and Bamber and Parkin proved that the clear liquid remaining after coagulation with acetic

acid often gave re-actions with the tests for proteins. The amount of protein in the clear liquor may, according to Bamber, be as much as 50 per cent. of the original. It may be asserted that a great part of these substances generally occurs in the prepared rubber, and their presence along with other substances leads in many cases to putrefaction.

PUTREFACTION AND TACKY OR HEATED RUBBER.

The protein matter is responsible for much of the "tackiness" or "heating," which is seen in many rubber samples. The rubber first becomes sticky, and sooner or later appears to melt as if exposed to excessive heat. It often emits a strong odour when in this stage. This is due to the inclusion of the proteins and perhaps the sugary and gummy constituents in the rubber and the subsequent development of micro-organisms on these substances. If the rubber is free from these materials it will not undergo such a change, and the removal of the latter from rubber takes us into several important methods of purification. The chemical change which takes place in tacky rubber is indicated in the analyses, made by Mr. M. Kelway Bamber, of sound rubber and material in various degrees of tackiness. They are here quoted in full:—

*Analyses of Sound and Tacky Para Rubber.**

	Sound Rubber.	Tacky No. 1.	Tacky No. 2.	Very Tacky
Moisture	.. 0.30%	.. 0.36%	.. 0.06%	.. 0.44%
Ash	.. 0.38	.. 0.28	.. 0.54	.. 0.72
Resin	.. 2.36	.. 2.32	.. 2.66	.. 3.70
Protein	.. 3.50	.. 3.85	.. 3.50	.. 4.90
Rubber	.. 93.46	.. 93.19	.. 93.24	.. 90.24
	<hr/> 100.00	<hr/> 100.00	<hr/> 100.00	<hr/> 100.00

These analyses show a relationship between the degree of tackiness and the percentage of proteins and resins; the latter may be due to oxidation. Too rapid drying is said to induce softening and tackiness in raw rubber.

USE OF ANTISEPTICS.

If the local conditions are such that the rubber cannot be prepared by any method other than coagulation, and the protein and other materials must be included, it will be necessary to take steps to keep the obnoxious ingredients in a quiescent state. This can be done by treating the latex with some reagent which has antiseptic properties, such as creosote or corrosive sublimate, and quickly drying the rubber after effectively washing and pressing the freshly-coagulated material.

MOISTURE, WASHING AND PUTREFACTION.

In some cases it is doubtful whether it is even necessary to add antiseptic reagents if the rubber is thoroughly dried, as decom-

* Committee of Agricultural Experiments, Peradeniya, Sept., 1905.

position is more or less dependent upon a supply of water being present. A communication from Messrs. Lewis and Peat on this subject is given in the chapter dealing with plantation and fine Para rubber.

No matter whether the latex has been treated with antiseptics or not, the coagulated substance should be very well washed; too much water cannot be used. In the washing processes the water may carry away a considerable portion of the soluble protein or that precipitated on the surface, and thus minimise the danger.

The use of washing machinery or antiseptics or both is almost certain to become a necessity in the near future, judging by the reports of European firms on the condition of various packages of plantation rubber which they have received. Dilution of the latex before coagulation might also reduce the proportion of protein in the prepared rubber. The quicker and more effectively the rubber is dried, the less likelihood there is of putrefaction or tackiness setting in.

REMOVAL OF THE PROTEIN FROM THE LATEX.

But it is not beyond the ingenuity of the chemist or planter to treat the latex with some reagent which will keep some proteins in solution while the caoutchouc globules are segregating; those which form part of the rubber can be expelled by subsequent pressing and washing. We have seen that Henri and Dunstan believe that coagulation can be effected after the removal of all protein substances from the latex.

Weber, as the result of experiments mainly with *Castilloa* latex, suggested that the treatment of dilute hot solutions of latex with formaldehyde (Formalin), or the use of the latter with sodium sulphate, may be effective in reducing the amount of protein matter in prepared rubber:—

“To every gallon of the rubber latex, from $\frac{1}{2}$ oz. to 1 oz. of formaldehyde (formalin 40 per cent. solution) is added, the latex well stirred and allowed to stand for one hour. Then to each gallon of latex a solution of 1 lb. of sodium sulphate (commercial) in one pint of boiling water is added while still hot, and the mixture stirred for some time. Coagulation may take place immediately or after several hours' standing, according to the condition of the latex. Great care must be taken to use a sodium sulphate of entirely neutral reaction.

“What actually happens is this: The diluted rubber milk, freed from all its mechanical impurities by straining, is, to begin with, rendered non-coagulable by the addition of the formaldehyde. On adding to the rubber milk the solution of sodium sulphate the rubber substance rapidly rises to the top, where at first it forms a very thick, creamy mass, the individual globules of which rapidly coalesce. The coalesced (and as a matter of fact, not coagulated)

Fig. 1.

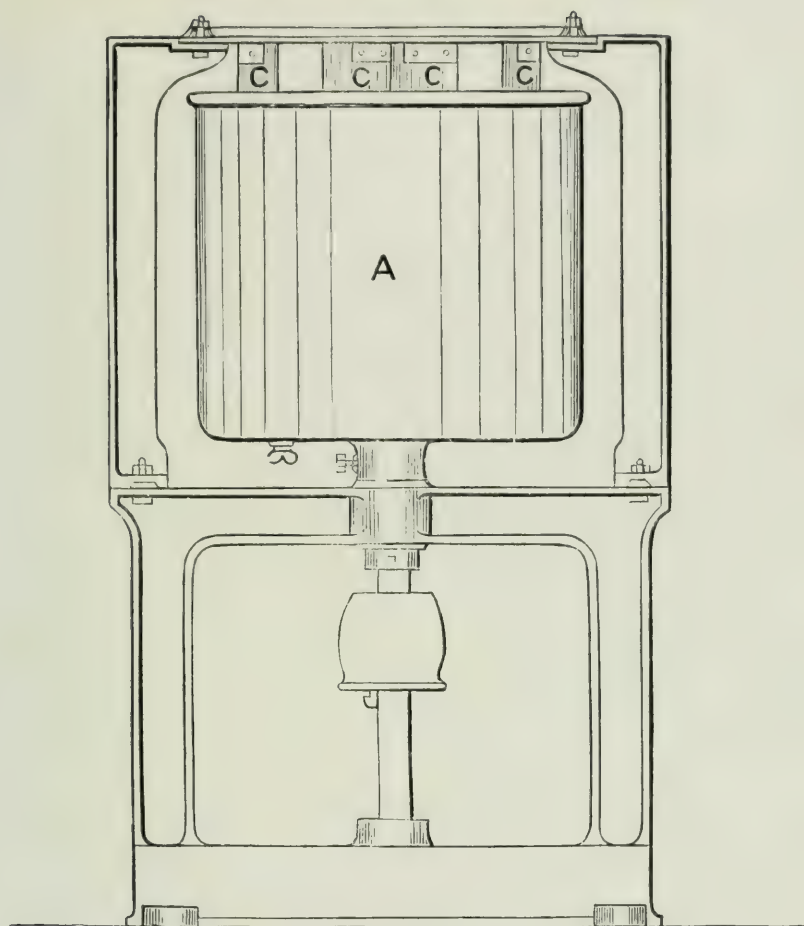
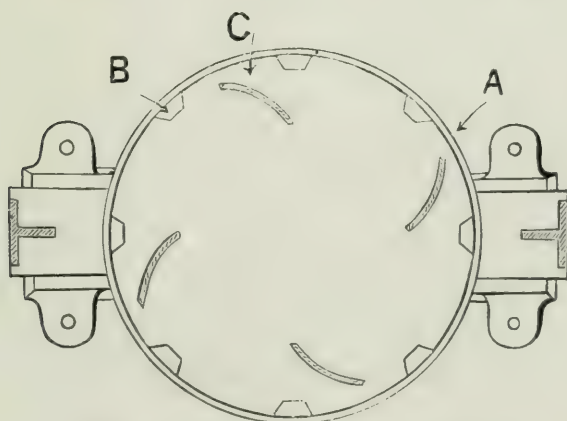


Fig. 2.



THE MICHIE-GOLLEDGE COAGULATOR.

mass, on being worked upon the washing rollers, undergoes a very curious polymerisation process, and thereby rapidly acquires the great strength and toughness so characteristic of high-class india-rubber.

“On cutting the cake open it will be found to be rather spongy, being full of little holes which are still filled with some of the albuminous, though very dilute, mother liquor. If, therefore, the rubber were dried in this state, it is obvious that it would still contain a small quantity of the objectionable albuminous matter. For this reason the rubber so obtained should at once be taken, cut into strips, and subjected to a thorough washing upon an ordinary rubber washing machine.” The formalin acts more as an antiseptic to prevent the decomposition of the protein than anything else, and does not affect the specific gravity of the mother liquor.

Johnson made several attempts, when Director in the Gold Coast, to separate rubber from Para latex in the manner above suggested, but failed in each instance, although the latex stood, in one or two instances, for nearly three weeks without the rubber separating out.

This method has been tried by many persons, and evidently requires further experiments before it can be pronounced as perfect. It should be remembered that certain reagents *e.g.* ammonia, serenguiana, &c., will keep the latex in a liquid state for a very long time, and might be used with advantage in such experiments

RAPID COAGULATION AND REMOVAL OF PROTEINS BY MECHANICAL MEANS.

It has been stated that mechanical appliances have been invented which can effectively eliminate the protein normally forming part of the latex.

Biffen's Centrifugal Machine.

Biffen* recognized that in latex the india-rubber existed as suspended globules, lighter than water, and employed for separating the caoutchouc, a centrifugal machine similar to that used in separating butter from milk. The machine was a modified form of the ordinary centrifugal milk tester, capable of being rotated 6,000 times per minute. The caoutchouc of Para latex is said to be effectively separated in a few minutes and to consist of the pure article, free from mixtures of proteins, resins, &c. Weber strongly recommended such a process of treating the latex for eliminating proteid constituents.

Biffen claims that the rubber may thus be prepared by purely physical means; the light rubber globules are thrown out of the bowl in an almost dry state, and the rubber is free from any obnoxious

*Biffen; *Annals of Botany*, June, 1898. *Journal of the Society of Arts*, 1898.

smell and danger of decomposition. It is, however, questionable whether pure caoutchouc free from resinous and other impurities is desired by the manufacturers.

EXPERIMENTS IN CEYLON.

Furthermore, several small experiments carried out in Ceylon have proved that the caoutchouc in ordinary Para latex is not rapidly separated by the centrifugal machine, even when the speed is as high as 11,000 revolutions per minute. In these experiments various heavy chemicals have been added to the latex after the formalin; the chemicals used do not show an acid reaction, and considerably increase the density of the alkaline mother liquor. The whole of this mixture has been placed in the "Aktiebolaget Separator," and then been subjected to centrifugal force for over an hour, and yet the caoutchouc globules have not been effectively separated from the other constituents.

Though these experiments cannot at present be considered a success, the principle of increasing the density of the mother liquor by addition of readily soluble and heavy substances, and then causing a separation of the caoutchouc globules by mechanical means, is one which cannot be too strongly impressed on the experimentalist.

RAPID COAGULATION BY MECHANICAL AND OTHER MEANS.

The Michie-Golledge Machine.

Construction.—On the accompanying plate a sketch of parts of this machine is shown. The Michie-Golledge Rubber Coagulating Machine consists of a revolving cylinder A, with angular ribs B on its inside, and curved blades C which are fixtures, as shown in the accompanying sketch. The latex is poured into the cylinder A, which is then set in motion, the machine revolving in the direction indicated by the arrow. The revolving cylinder and its ribs B force the latex forward on to the blades C, which carry it into the centre of the cylinder, creating a kind of vortex or whirlpool, and depositing the rubber in the central space in the form of a sponge-like mass. When the mass of rubber reaches the right consistency, it is removed by hand, separated into lumps of the required size, and rolled out while it is still soft into sheets in a small rolling machine.

Method of Using.—The latex is diluted, often as much as 400 per cent., and after being strained to remove the mechanical impurities and treated with acetic acid in the proportion of 1 dram of acetic to 1 gallon of the diluted latex, is placed in the churn-like cylinder. The cylinder is then rotated horizontally at the rate of about 180 revolutions per minute for about $1\frac{1}{2}$ minute, after which the speed is reduced to about 100 revolutions per minute for the next $3\frac{1}{2}$ minutes. The coagulated latex accumulates in the centre, and the watery portion remains in the outer part between the vertical plates and the wall of the cylinder. When the watery portion is clear the separation of the rubber is considered to be complete, and the



THE MICHIE-GOLLEDGE COAGULATOR

THE SPONGY MASS OF FRESHLY COAGULATED RUBBER IS SHOWN AT THE TOP.

Photo by C. H. Kerr.

coagulated latex is removed. The freshly-coagulated mass is, as shown elsewhere, in the fresh state very spongy, and is torn into irregular pieces which are pressed between the rollers of a mangle. A figure of the mangle used and the cakes obtained is shown on the accompanying Plate; the irregular cakes, obtained by passing the spongy mass through the rollers, are then cut into worm-like threads by means of shears worked by hand; the "worms" are next placed on wooden shelves to dry. The rubber so prepared may at first contain most of the ingredients present in the latex, the soluble portion of which may be partially removed by repeatedly washing the rubber during the rolling process. Two analyses of this rubber are given elsewhere.

Mathieu's Apparatus.

An apparatus for coagulating rubber in large quantities by means of heat alone has been considered by Mathieu, which follows in principle the manipulation of the latex as practised by the Brazilian *seringero*. As far as I can understand it, the apparatus is devised to subject thin films of the latex to the action of a surface heated to a constant degree, and can be worked *in situ* or be put on wheels and transported to any part of the estate where collecting operations are being carried out. Dickson's drying and coagulating machine is described in Chapter XIV. of this book.

A NEW COAGULATOR.

A new coagulator invented by Mr. Harvey, of Pataling estate, and known as the Kuala Lumpur Coagulator was exhibited at a recent exhibition at Kuala Kangsar. Compared with other processes the new coagulator is said to require only a fraction of the amount of coagulant ordinarily used, and is capable of turning out sponge-rubber, ready for further manipulation, in from 6 to 10 minutes, according to the age of the trees from which the latex is taken.

THE "K. L." COAGULATOR.

Mr. Harvey, in describing his machine, writes to the Federated Engineering Company Limited as follows:—

1. This machine has been designed to fill a long-felt want in the up-to-date rubber factory. It occupies very little room and effectively does away with the need for coagulating pans and racks, thus saving space and labour.

2. Latex can be strained directly into the machine immediately it arrives from the field, and a perfect coagulation can be effected in five minutes. Thorough bulking of latex is assured.

3. By the use of this machine all decomposition of the proteids contained in the latex is rendered impossible, and when the coagulated rubber is washed through a machine there is an entire absence of that unpleasant odour so associated with new rubber which has been coagulated in pans.

4. The out-turn of dry rubber will be found to be more even in colour.

5. The large machine is capable of dealing with 50 gallons of latex at one time, while the smaller size treats 30 gallons.

6. It can be worked easily by one cooly, and needs no pulleys or belts. Nor is it necessary to set the machine in concrete.

7. The machine is portable, and can be cleaned with ease, with fair usage it is impossible to get out of order or broken.

8. The price is less than one third of any other coagulating machine on the market, and its capacity is four times greater.

INSTRUCTIONS FOR USE WITH "K. L." COAGULATOR.

The following solution of Acetic acid has been found to give good results for coagulation.

6 of water to 1 of Glacial Acetic, and

1 $\frac{3}{4}$ fluid ozs. of solution to every 4 gallons of latex.

Having strained the latex into the coagulator, turn the handle slowly while pouring in the solution; the latter should be poured in slowly, so as to be as widely diffused as possible throughout the latex

The solution having all been poured in, continue to turn for about five minutes, a medium pace should be maintained and the handle occasionally reversed for a turn or two.

Supposing there to be about 35 gallons of latex in the coagulator, it will be noticed that coagulation starts in about five minutes, and when once this is the case, it will be found best to let it stand and then turn again in alternate spells of short duration; quantities of 30 to 50 gallons of latex may be coagulated in about six to seven minutes.

An illustration of this apparatus is shown elsewhere.

COAGULATION IN THE FIELD OR FACTORY.

On most estates the latex is collected in the field and despatched to the factory, in pails carried by hand or in tanks along a monorail, where it is almost immediately coagulated. It is obvious, however, that a large quantity of water is thus transmitted; in order to effect economy several planters have suggested that coagulation should be done in the field and only the freshly-coagulated rubber need then be carried to the central factory. Mr. Gollodge, Gikiyanakanda, informed, me that he proposed to erect small sheds each equipped with a coagulating machine on every hundred acres of land; the coagulated rubber from each shed could then be carried to the factory for final manipulation.



THE "K. L." COAGULATOR.

CHAPTER XIV.

DRYING OF RUBBER.

General Methods—Illustration showing the method of drying biscuit rubber—Water, putrefaction and surface deposits—Chemicals and artificial heat for drying—Water in wild and plantation rubber—Removal of moisture from plantation rubber—Immediate removal of moisture from rubber by manufacturers—Effect of moisture on the strength of rubber—Reduction of moisture and increased strength—Experiments by Schidrowitz and Kaye—The tensile strength, elongation and resiliency of dry and moist Funtumia rubber samples—Water in and price of rubber—Creosote and wet plantation rubber by Bamber and Willis—Manufacturers against wet plantation rubber—Methods of drying in the East—Exposure to the air—Cold air currents—Hot air rooms—Vacuum drying—Method of using Passburg's drier—Vacuum dryers in the F. M. S.—Advantages of vacuum drying—Rapid and slow drying—Manufacturers often prefer slowly dried rubber—Bubbles in rapidly dried rubber—Rapid drying without vacuum driers—Dickson's machine for coagulating and drying rubber—Use of calcium chloride—Hot air chambers and the use of hygroscopic chemicals.

ON most estates the freshly-coagulated rubber is rolled to drive out as much water as possible, and then either hung up on cords or placed on shelves made of coarse wire netting, coir matting, or wood, and allowed to dry. The rubber cannot be dried in the sun, though a current of warm dry air may be used without any bad effect. The ordinary cacao and tea-drying factories might easily be used for this purpose. The preparation of the rubber in sheets as thin as possible is desirable in order to obtain a dry rubber in the shortest time, though a minimum thickness of one-eighth of an inch is preferred by buyers in Europe. Though the drying process may be hastened by various methods, it is well-known that rubber of good quality can be produced without resorting to any devices for hastening the drying or curing of the product. The illustration given elsewhere shows a simple method of drying biscuit rubber as adopted on many rubber estates. Crêpe, flake, worm and lace rubber are capable of being dried more rapidly than thick biscuits or sheets.

The presence of water in the rubber is often a serious drawback, and the fact that the rubber, if dry, will not undergo putrefactive changes is of sufficient importance to warrant attention to this part of the subject. It should be remembered that when the biscuits or sheets are hung up to dry the evaporation of the water is followed by a deposition of the suspended or dissolved impurities on the surface of the rubber they should be removed. Immediate drying is essential in order to prevent deterioration consequent on oxidation; too rapid drying is said to induce a softening of the rubber.

CHEMICALS AND ARTIFICIAL HEAT FOR DRYING.

Parkin* stated that to dry rubber by heat did not seem advisable, and suggested that perhaps quicklime or calcium chloride might be used in the drying chamber.

Burgess† states that the raw rubber, before it is vulcanized, is very sensitive to heat, and a temperature of 150° F. may render Para rubber sticky on the surface, and a higher temperature utterly destroy the "nerve" of it; he declares that it is, therefore, dangerous to use artificial heat in hastening the drying of rubber. He also states that if artificial heat were absolutely necessary a very carefully regulated temperature, never exceeding 120° F., would probably not cause any great damage.

Weber‡ asserted that certain brands of india-rubber cannot be hung up to dry in the form of sheets after the washing process, as they become so soft as to fall to pieces. The temperature at which india-rubber begins to soften varies according to the percentage of resinous and oily substances present; many samples of good Para rubber pass into a more or less fluid state at about 170 to 180° F.

WATER IN WILD AND PLANTATION RUBBER.

The majority of rubber exported from the various African and American ports contains a large proportion of impurities; even fine hard Para and Lagos lump frequently possess over ten per cent. of water alone on their arrival in Europe. Many of the wild rubbers exhibited in the ordinary London sale room can, by means of hand pressure alone, be made to eject water in quantities indicative of there being about twenty per cent. of moisture alone in the crude samples. This variation in the moisture contents naturally affects the proportion of caoutchouc, the value of the rubber to the manufacturer, and therefore the price realized. In marked contrast to this is the almost dry rubber received from well-managed Eastern plantations; this freedom from moisture and consequent constancy in composition is largely responsible for the agreement in average prices realized for consignments of Para rubber from innumerable estates in Ceylon and Malaya. The production of rubber free from moisture may involve the erection of certain machinery and necessitates a certain amount of delay in delivery.

REMOVAL OF MOISTURE FROM PLANTATION RUBBER.

The desirability of removing the moisture from plantation rubber has been discussed in many quarters and the subject raises numerous points of interest. In the first case it should be remembered that the difference between wild and plantation rubbers is not one of moisture alone; a series of factors such as the proportion of putrescible matter and its state of preservation, the age of the

* Parkin, *J. c.* p. 151.

† Burgess, Lecture at the Agri-Horticultural Show, Kuala Lumpur, 1904.

‡ Chemistry of India-Rubber, p. 21.

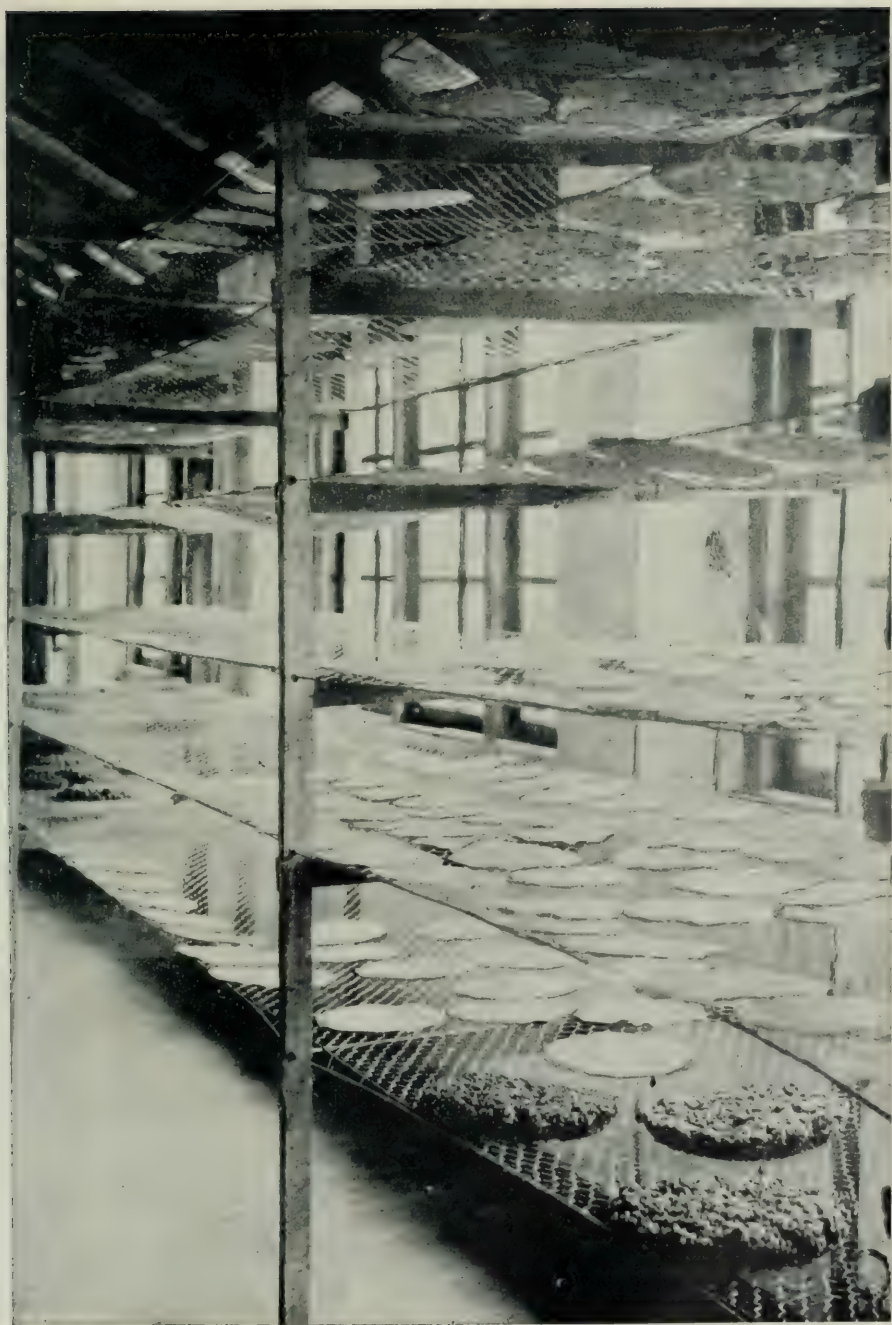


Photo by Ivor Etherington.

DRYING BISCUIT RUBBER.

trees whence the rubber was obtained, etc., all play a part in giving to wild rubber its general characteristics. So far the results of scientific experiments with wet and dry rubber have not been published, though much has been written by interested parties in the East on this subject.

An advisor to Messrs. Lewis and Peat pointed out in 1906 that "Ceylon and Straits biscuits and sheets are at present made too pure—*too much moisture* being taken out of the rubber—with the result that the elasticity and strength are reduced; such rubber, it is stated, will not keep, but inevitably becomes soft and treacly if stored for any time or subjected to pressure and a raised temperature."

The same advisor goes on to suggest that it is the extra moisture left in the fine Para "smoke-cured" that renders it fit and strong enough for all purposes, and accounts for it not deteriorating after being kept for any length of time. To this the Editor of the 'India-Rubber Journal' (April, 9th, 1906), replied "if this is so, why do the manufacturers, as soon as possible after there arrives in the factory a delivery of rubber, put it through the washing machine, and prefer to stock it as dry sheet rather than in the state in which it arrives? The answer is, simply because that thoroughly washed and dried rubber under suitable conditions will not deteriorate until after a very long lapse of time. The manufacturers' dried rubber contains no moisture at all, and in the old days it used to be stocked for two or three years before being used for special purposes. It therefore cannot be on account of the lack of moisture that the rubber deteriorates." It is finally suggested that the plantation rubber should be smoked and made up into large balls, bottles, or cakes, as in Para. The same firm in their circular dated December, 1905, stated that "*the very greatest care* should be taken that all rubber is *absolutely dry* before being packed." Obviously, in the opinion of Messrs. Lewis and Peat, the question of how to prepare the rubber for the market was, at the time, a vexed one and deserving of much experiment.

Mr. C. Devitt, when lecturing at the Ceylon Rubber Exhibition in September, 1906, stated that "one of the most important points in the packing of plantation rubber is, to get it absolutely dry and quite free from surface moisture before shipping, as any dampness, even if it is only on a few biscuits or sheets, is likely to ruin a whole case-full. We very often find where moisture has been left, the rubber has turned white and decomposition has started, making it unsightly, weak, and evil-smelling."

It will be noticed that the above remark was made with special reference to the surface moisture and not, apparently, to that which might be included between the layers of rubber.

EFFECT OF MOISTURE ON STRENGTH OF RUBBER.

Bamber, after giving the analyses of various rubbers, states, in the Official Handbook to the Ceylon Rubber Exhibition, that

"A careful study of the figures shows how difficult it is to form deductions as to what gives actual strength in the rubber, for the strongest rubbers have not necessarily the most caoutchouc, though the difference of 1 per cent., in such high numbers as 93 to 95 per cent. would have very slight effect".

He further says, on the subject of moisture and strength:—"The theory that more moisture left in the rubber would add to its strength is apparently not borne out by the above figures." In view of this statement it is difficult to understand the claims which Bamber subsequently made in connection with the preparation of wet, creosote, rubber detailed elsewhere.

REDUCTION OF MOISTURE AND INCREASED STRENGTH.

Messrs. Schidrowitz and Kaye, in their paper* on "The Influence of the Method of Coagulation on the Physical and Chemical properties of *Funtumia elastica*", point out that, as might have been expected, the method of coagulation has an important bearing on the chemical and physical properties of Funtumia. It is worthy of note that the reduction in moisture from (in the highest case 12.64) to a mere trace results in every case in an appreciable increase both in tensile strength and distensibility. This is of particular interest in view of the fact that fine hard Para contains considerable more moisture than any of these moist samples. It is probable that in the moist Funtumia samples the moisture is present in a quasi-molecular state whereas in fine hard Para the remanent moisture is merely mechanically admixed. It is perfectly plain that every variety of rubber must be separately considered in regard both to coagulation and methods of drying, &c. It will be noticed that the dry samples gave in some cases very high figures for the physical tests. It has been sometimes asserted that to dry rubber too much makes it harsh and brittle. These results show that if this is so, it is not due to the removal of the moisture, but to the manner in which it is removed.

The extent to which moisture should be removed must depend, according to Schidrowitz and Kaye, on the class of rubber being treated and the manner of coagulation. It does not necessarily follow that rubber which is packed somewhat moist will on arrival and after washing and drying by the manufacturer, give worse results than a rubber which is shipped very dry. It depends on whether the conditions of preparation of the crude rubber are such that an appreciable quantity of moisture is dangerous as regards mould formation or not. From the results obtained by themselves, and other experiments with plantation rubbers, they were led to conclude that a systematic examination of the latices and methods of coagulation of Hevea rubbers would result in a very great improvement in much of the plantation rubber put on the market; the following is an extract from their table of analyses:—

* India-Rubber Journal, Sept. 23rd, 1907.

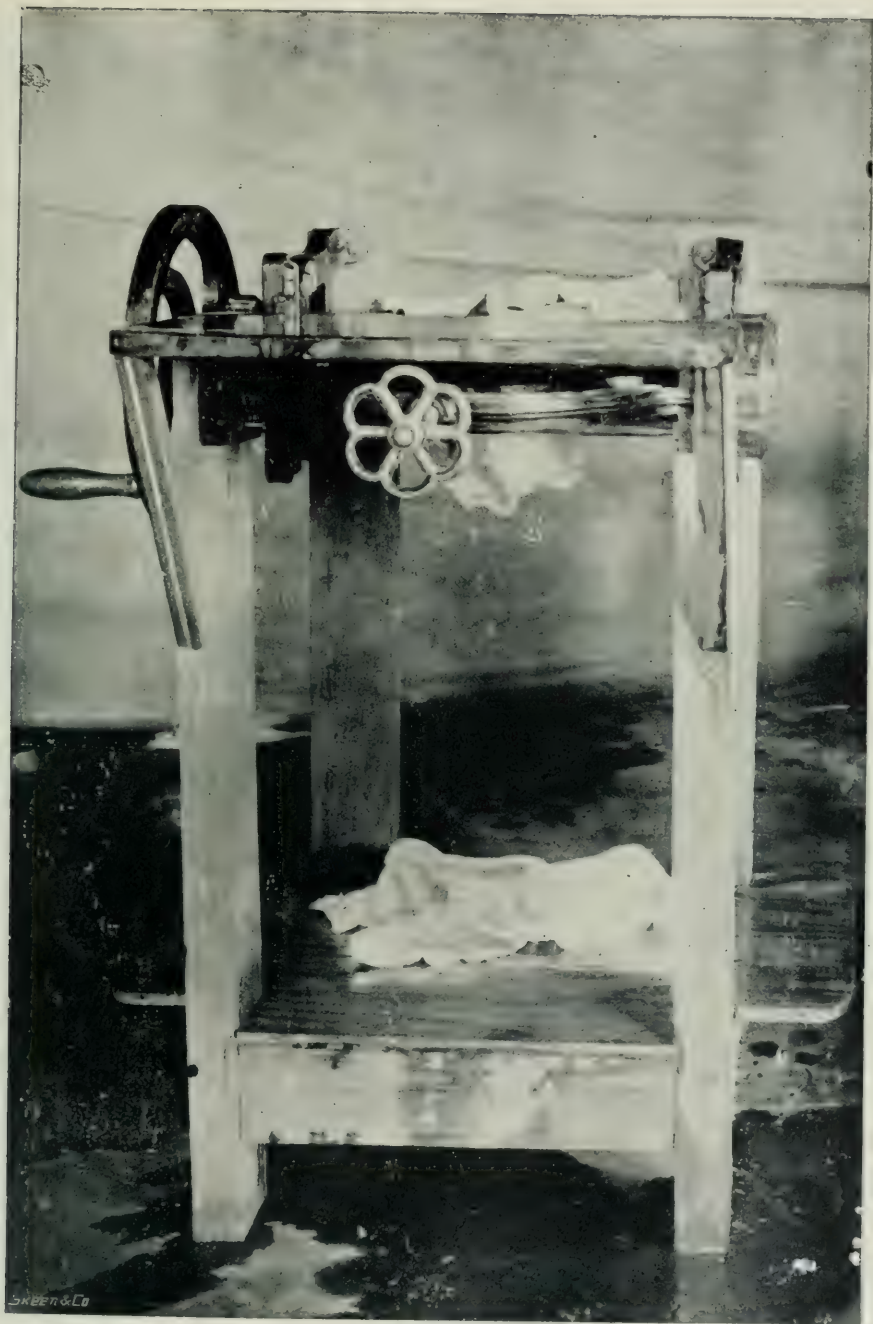


Photo by C. H. Kerr.

MACHINERY FOR EXPELLING WATER.
SPONGY RUBBER PREPARED BY THE MICHIE-GOLLEDGE PROCESS.

RESULTS OF EXAMINATION OF SAMPLES OF RUBBER OBTAINED BY VARIOUS METHODS (AS INDICATED) FROM ONE SAMPLE OF FUNTUMIA ELASTICA LATEX.

	No. 1	No. 2	No. 4	No. 6	No. 7	No. 9	No. 11	No. X.
	Heated at 25° C., warmed with fresh quantities of water and boiled up at 100° C. several times (until colorless). Then pressed and dried in a vacuum (at 40° C.).	Boiled for five minutes. Pressed lightly with water and boiled up with more water again. Finally pressed and dried in a vacuum (at 40° C.).	Treated with ammonium oxalate and calcium chloride.	Precipitated with acetone 1:3. Pressed and dried as others.	Creamed with water 1:3. Pressed and dried.	Diluted with CaCl_2 (10%) after a week added a little ammon. ox. and heated to 100° F. Pressed, etc.	Boiled. Then boiled coagulated with more H_2O . Pressed and then treated with resin heated to 100° F. Pressed and dried in a vacuum.	Precipitated from latex by exactly neutralising with alkali.
Moist Tensile Strength (breaking strain) in grams per sq. mm.	120	190	150	117	190			—
Dry Tensile strength.	—	293	308 (Almost dry) 392 (Quite dry)	217	290			384
Moist Elongation.	6.0	4.25	4.4	3.8	5.5			—
Dry Elongation.	—	5.0	5.0 (Almost dry) 6.0 (Quite dry)	5.5	6.4			4.5
Resiliency—(dry %)	—	66%	67%	80%	94%		54%, 100%.	—

NOTES.— The "moist" tensile strengths were determined in the rubbers displaying the figures as shown in the above table. Part of the samples were then completely dried (until quite clear) in a vacuum at 40° C. The "dry" tests refer to the samples so treated. The "Resiliency" is arrived at by expressing the original length of the strip tested as a percentage of the length of the strip at the breaking strain, measured after a period of 24 hours had elapsed after the test was made. A sample which returned to its original length after this period would therefore have a resiliency of 100.

WATER IN, AND PRICE OF, RUBBER.

It is obvious that when rubber varies in its water content the price paid for the crude material will also vary, and only where the rubber is free from all impurities and of relatively constant composition will the price be at all constant. It is the habit of some buyers of crude rubber to test the samples for their water and grit by hand only, though no one doubts the impossibility of thus accurately estimating the percentage of moisture in samples from various sources. The present prices for fine hard Para and plantation Para are 3s. 2d. and 3s. 6d. per lb. respectively; the former contains about 20 per cent. and the latter less than 0.5 per cent. of water, so that the price paid for fine hard Para is, pound per pound of dry rubber, more than that paid for plantation. This increase in price paid for fine Para is as it should be owing to the superior qualities of fine Para when compared with that from ordinary plantations; it does not mean that plantation rubber is getting a lower price on account of its not possessing water; the difference paid is no logical reason why any person * should have suggested the shipping of plantation rubber containing a higher proportion of water.

CREOSOTE AND WET PLANTATION RUBBER.

Messrs. Bamber and Willis † recently carried out experiments to test the possibility of sending home undried rubber preserved with the aid of creosote. Acetic acid and a mixture of creosote in methylated spirit, were added: as soon as coagulation was complete, the mass was cut up and washed, and then blocked for two or three hours in a wooden mould in a screw press. The block so prepared contained from 8 to 9 per cent. of water, but the authorities thought that this might be reduced to 7 per cent. if necessary.

Samples prepared in the above manner were valued at 5s. 6d. per lb. Messrs. Bamber and Willis pointed out that as ordinary Ceylon plantation rubber contains less than 1 per cent. of moisture, the price obtained for the experimental samples was equivalent to 6s. a pound for the actual rubber they contained. The actual sales on the same day were "Culloden" 5s. 9½d. and on seven other estates 5s. 7½d. The rubber therefore obtained a price 3d. better than the exceptionally good lot sent from Culloden; this compared very favourably indeed with any previously realized, though it was not up to that of fine Para from South America.

* Tropical Agriculturist, Colombo, November, 1906.

† Circular R. B. G., Peradeniya, January, 1907.

The following analyses by Bamber show the composition of the wet rubber after drying ten days, and the average of good Ceylon biscuits:—

CREOSOTED WET RUBBER		AVERAGE CEYLON BISCUIT.	
	per cent.		per cent.
Moisture	.. 7.06	..	0.45
Ash ..	... 0.18	..	0.34
Resin	.. 1.92	..	2.01
Proteins	.. 3.67	..	2.37
Caoutchouc	.. 87.17	..	94.83
	<hr/> 100.00		<hr/> 100.00
Nitrogen	<hr/> 0.58		<hr/> 0.37

Messrs. Bamber and Willis concluded that the planters were removing too much from their rubber, especially in the way of moisture, and that in future it would be advisable to block rubber in the wet condition, provided it was rendered antiseptic by the use of creosote or other preservative.

From this experiment they concluded, “that it is evident that the erection of large factories for the mechanical treatment and the drying of rubber would be premature.”

The experiments are of considerable interest, and though the hasty deductions arrived at were not warranted from the results obtained they should be borne in mind. It is perhaps, needless to point out that rubber manufacturers will not pay very much for water; they generally prefer uniform and pure plantation rubber.

MANUFACTURERS AGAINST WET PLANTATION RUBBER.

The users of plantation rubber are, in virtue of their long association with rubbers of many kinds, able to give very sound judgment on the question of sending plantation rubber home in the wet or dry state. The “India-Rubber Journal,” in their issue of September 23rd., 1907, gives the following account of the opinions of manufacturers on this point:—

“In view of the publicity which was some time back given to the valuation of a small sample of wet creosoted block rubber, the recommendation which the experimenters gave, and the arrival of rubber containing moisture and creosote on the London market, we considered it advisable to approach, direct, the users of wet and dry rubber. The question put before them was: “Do you prefer to receive plantation rubber in the pure and dry

state or with water and creosote?" If manufacturers will pay a price for wet plantation rubber which will give the planter a return equal to or better than that realized for the dry material it will be a great advantage, and will allow the producers to turn out their rubber in the minimum time and, as pointed out by Messrs. Bamber and Willis, the erection of costly drying apparatus will not be necessary. It would, furthermore, give rubber to the manufacturers in a condition very similar to that in which the bulk of their present supply arrives, and perhaps result in the physical improvement of plantation rubber. The questions of whether the manufacturers required the rubber in the wet and creosoted condition, what improvements, if any, were effected in the physical properties of rubber so shipped, were, however, not known when Messrs. Willis and Bamber published their circular in January 1907. The publication was condemned in this Journal early in the year, and as the manufacturers have had time to carry out their own experiments, their verdict is worthy of every consideration. The replies have been shown to a London representative interested in the original wet creosoted rubber, and we only regret being unable to quote the names of the firms who have favoured us with their decisions. One manufacturer, who has condemned plantation rubber all along the line as an inferior product, and who has not yet been convinced of any special purposes for which it is useful, (though he guarantees its uselessness for certain articles) declares that he is quite indifferent as to whether the plantation product is dry, pure, wet or treated with antiseptics, as in every condition it has, so far, been unsatisfactory. We are glad, however to know that this opinion is not universally held, and that some manufacturers find purposes for which plantation rubber is specially useful. They are, with the above exception, all in favour of first-grade plantation rubber being in the dry and pure state. The following are the exact replies of several firms in reply to the question given above:—"Dry state"; "Pure and dry"; "Pure and dry state"; "Pure and dry state most decidedly". This unanimity among manufacturers using the rubber for entirely different purposes came as a surprise to us. Not a single firm replied to the effect that they preferred the rubber in the "wet and creosoted" condition; they plumped for the "dry and pure state". We are naturally satisfied to have such a general confirmation of our views, and if only the planters in the East will realize how important it is that their rubber shall always be at the top for price, purity, and constancy, even if the maintenance of that reputation necessitated what, for the present, appears almost unnecessary expenditure, we think they will be well advised. The cheapening of the processes of production does not tempt those proprietors who know the value of keeping their product in the front rank in every respect; we trust that no recommendations will be issued until the opinions of manufacturers have been secured on the samples submitted."

In the same issue the "India-Rubber Journal" states that many of the manufacturing firms have written suggesting that the purity and quality of plantation rubber should be maintained; the general tendency of the requirements of the manufacturers, appears to be that they are not certain of the purity of the rubber which will come, or is now coming, from plantations in the East; they are, more or less, unanimous in their requests for the delivery of rubber in as pure a condition as possible.

METHODS OF DRYING IN THE EAST.

Putting all theoretical considerations aside and assuming that the planter desires to turn out rubber in the purest possible form and that the greater part of the water must be removed, there are four methods which can be employed.

EXPOSURE TO AIR.

The first method consists in exposing the latex on banana or other large leaves to the sun and subsequently peeling off the thin layers of dry rubber and rolling them into a ball or block. This is a practice which does not require any machinery but it is one which cannot be recommended on account of the liability of the rubber to turn soft and sticky on exposure to the sun. It is, nevertheless, carried out on some native plantations.

COLD AIR CURRENTS.

The second method is that of drying the rubber in dark rooms kept at ordinary temperatures. The length of time required to dry the rubber under such conditions is determined by the circulation of air through the room and the thickness of the rubber. Under ordinary conditions, with rubber prepared in thin sheets or crêpe an interval of weeks or months must be allowed for the slow drying process. This is obviously a very poor method, though it is used by persons who believe that a better product is obtained by allowing the rubber to dry very slowly. It is not, however, in their interests to thus keep the rubber in the store, because, apart from financial considerations, it is liable, when exposed for such a long period to become tacky on the surface or mouldy.

HOT AIR ROOMS.

The third method is that of using hot air chambers provided with shelves along the sides and in the middle of the room. The temperature is maintained at about 90 to 100° F., by means of hot air drawn through the building by means of a fan, or by means of steam pipes running round the building. This is a method which, to dry rubber of $\frac{1}{8}$ to $\frac{1}{4}$ inch in thickness, may require one to two months and on that account is obviously one which cannot always be recommended for estates dealing with

large quantities of rubber. If this method is adopted the temperature of the room should never be allowed to rise above 120° F.

VACUUM DRYING.

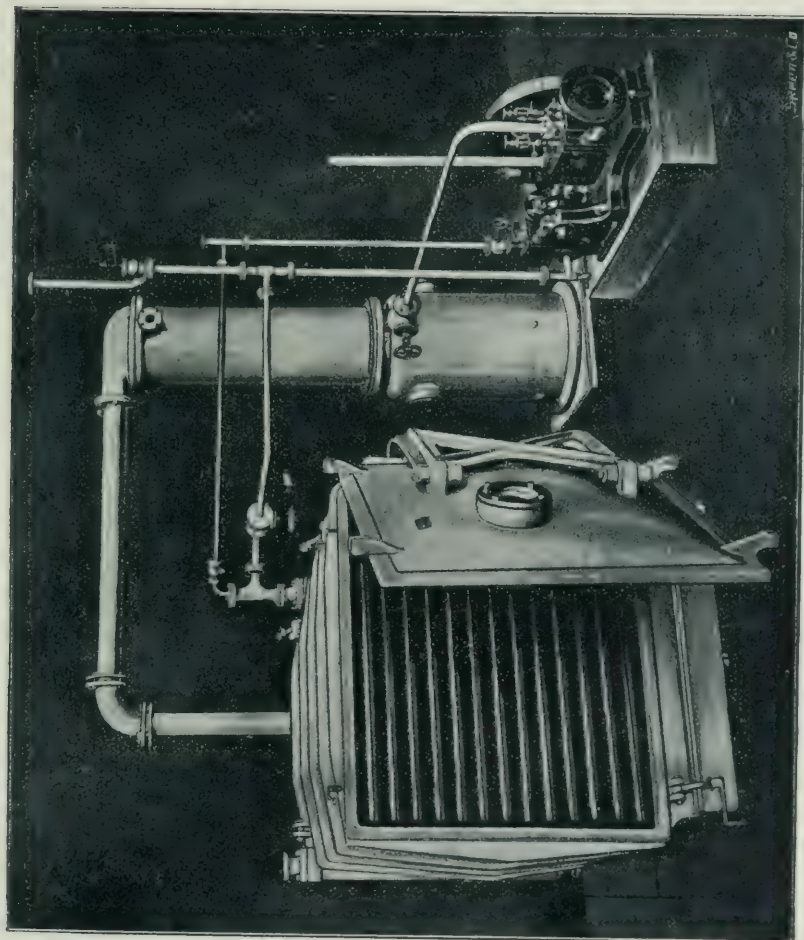
The fourth method is that of drying in vacuum chambers.

In the "India-Rubber World" (November 1, 1905) a suggestion is made that the principle of drying rubber in vacuo might be tried. It is maintained that drying in vacuo is accomplished rapidly, only low temperatures are necessary, and a great saving in fuel, space, and labour is effected. The vacuum drying chambers may be obtained in rectangular and in cylindrical styles and fitted with plate shelves or shelf coils inside. According to Burgess, a vacuum chamber consists of a large iron box, of from 100 to 200 cubic feet capacity, fitted inside with shallow trays with perforated bottoms, and heated with steam pipes, the interior being connected by an iron pipe with an exhaust pump. The temperature of the chamber is raised to 120 to 130° F., and after the air has been drawn through the chamber for a few hours the rubber is usually sufficiently dry for most purposes. Most manufacturers, however, have not adopted drying in vacuo, as they believe the rubber is softened by the heating and the nerve and quality of the rubber injured, but prefer to dry the rubber gradually in dark warm rooms.

This method, which is now being rapidly taken up on some of the most prominent rubber estates in the East, applies equally to all kinds of rubber and enables one to manufacture rubber nearly dry in a sound state, ready for making up into blocks. In a vacuum chamber one can dry ordinary biscuit, sheet, or crêpe rubber. The rubber is allowed to remain in the vacuum chamber until only about 1 per cent. moisture is left in the rubber. When in that condition it should be removed, as if allowed to remain until the whole of the moisture is extracted the rubber seems very liable to resolve itself into a soft treacly mass. The temperature and pressure inside the chamber, can, with a little skill, be easily regulated and providing the whole of the moisture is not extracted, good results can be anticipated. The quantity of rubber which can be dried in a given time by means of a vacuum chamber depends upon the capacity, but those with which I have concerned myself are capable of dealing with 330 lb. of rubber at a time, and in ordinary rubber factories can deal, in practice, with large quantities of wet rubber in 24 hours.

METHOD OF WORKING PASSBURG'S DRIERS.

The time that the rubber remains in the chamber is usually from 1½ to 1¾ hours. The steam supply is shut off about a quarter of an hour before the rubber is dry. The heat in the metal of the chamber completes the last stage of the drying. When the vacuum is about 28½ inches the temperature of the rubber remains



PASSBURG VACUUM DRIER.

at about 90° F. until the greater part of the moisture has been removed. It then slightly rises and is taken out when the chamber reaches about 120° F.

In the Federated Malay States they are, at the present time, using a very low steam pressure in the shelves—from 1 to 4 lb. only—and on some estates they leave the rubber in for 1½ to 2 hours. When they desire more output from a chamber they will probably increase the steam pressure and shorten the drying time. At the end of the drying process the rubber is hot and relatively soft, and is specially suitable for cutting into strips and conversion into block. You cannot make satisfactory dry blocks without using the vacuum chamber, as it not only gives a dry, but a soft product, easily manipulated. The warm rubber on cooling sets into a hard block and does not retain the pliable character of the warm material.

Vacuum drying is generally resorted to, when it is advisable to remove the moisture without subjecting the product to a high temperature.

It has been argued that when drying in vacuum chambers there cannot, owing to the absence of air be any oxidation; this is to some extent a wrong view to take as a small quantity of air will probably remain in the vacuum chamber however excellent the exhaust.

It is obvious from these considerations that the vacuum method is one by means of which rubber can be dried in the shortest time, and material turned out approximately pure and uniform. On some estates they have been described as “useless,” and on others as “indispensable;” the success with which such a complicated piece of apparatus is used depends, very often, on the engineering skill of the planter in charge.

RAPID AND SLOW DRYING.

It has been previously explained that in view of the fact that many of the larger plantations are harvesting very large quantities of rubber which they desire to dispose of as quickly as possible, methods of drying, other than the use of ordinary heated curing houses, will become more common. It is well known from experience on many plantations in the East, that by means of vacuum dryers rubber can be cured at the rate of 200 to 330 lb. per two hours; this represents an output which is anticipated on many properties. But as to whether the rubber is in any way damaged by such rapid drying, opinion seems to be divided. The replies, received from manufacturers who have been consulted as to whether they would recommend planters to dry their rubber slowly or in vacuum chambers, are all against rapid drying; they all state that the best rubber is obtained when it is slowly dried.

When rubber is rapidly dried there is a tendency to the formation of an impervious skin on the surface owing to the superficial layers being dried before the internal portion; when one is dealing with very thin sheets or crêpe this drawback against rapid drying is not very formidable.

BUBBLES AND VACUUM DRYING.

Attention has been called to the number of air and steam bubbles occurring in some samples of sheet rubber dried in vacuum chambers. Many explain this by stating that when the wet sheets are placed in hot chambers a film forms on the surface, which, to some extent, prevents the escape of air or steam; if the temperature is then lowered very suddenly the air or steam may never escape, and the bubbles therefore remain to disfigure the rubber. Slowly-dried, thin, sheets do not usually show this disfigurement to the same extent, and one may safely conclude that the method of drying is therefore at fault. These bubbles occur just as abundantly in an average lot of crêpe rubber cured in vacuum chambers, but when the rubber is presented in this form the bubbles do not show up very conspicuously. The steam bubbles are formed as soon as a partial vacuum is secured, the water boiling under the reduced pressure at a comparatively low temperature. This feature in vacuum-dried rubber cannot be regarded as a very serious obstacle, especially if the planters must convert the hot, dry, rubber into loaves or blocks in the minimum time.

RAPID DRYING WITHOUT VACUUM DRIERS.

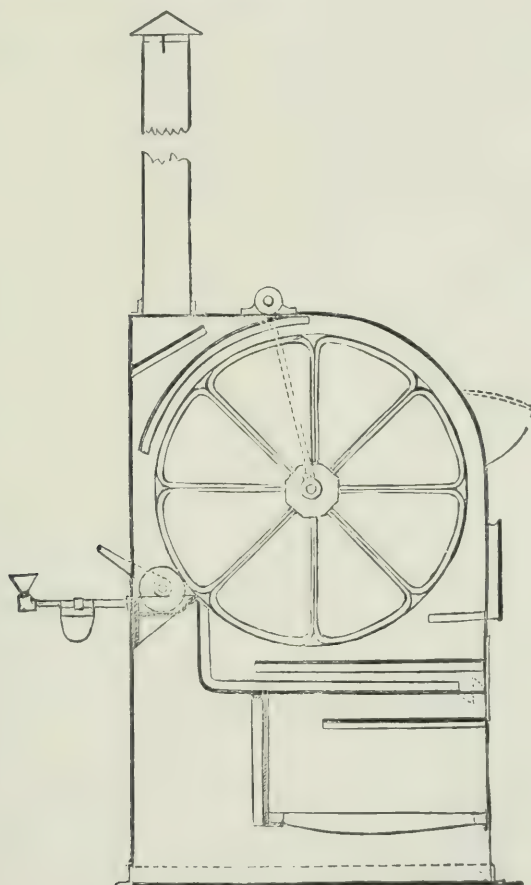
Mr. Golledge, Gikiyanakanda, Ceylon is, by means of his system, able to prepare dry crêpe rubber, without the use of vacuum driers, in 12 hours. The freshly coagulated rubber is cut into worms and the latter dried on trays in a wooden chamber maintained at 85° F. After 12 hours the worms are dry and on being passed between an ordinary pair of dry horizontally-fluted, iron rollers, are united into a continuous even strip of crêpe rubber. Somewhat similarly rapid conversion into dry rubber was done in Matale with lace rubber.

DICKSON'S MACHINE FOR COAGULATING AND DRYING RUBBER.

Mr. Dickson has kindly supplied me with the following description of his machine:—

“This machine consists of a small furnace, on the top of which is a smoke box containing a revolving drum. Between the furnace and the smoke box is a series of baffle plates to divert the fumes and ensure that no flames and sparks pass into the smoke box. At one side is a shallow pan for receiving the latex. In this pan is a small roller partly immersed in the latex, with its surface in contact with the surface of the large drum. A fire is placed in the furnace, and the fumes are allowed to pass between the

— RUBBER COAGULATING & DRYING MACHINE —



DICKSON'S COAGULATING AND DRYING MACHINE.

baffle plates and round the large drum to the chimney. When the desired temperature has been reached the pan is filled with latex from the feeder, and the small roller is turned by hand or power.

"The surface of the small roller being in contact with the surface of the large drum turns it, and at the same time spreads a thin film of latex on its surface. The action of the heat and fumes on the thin film of latex coagulates and dries it. Continuing the process the latex is spread film by film, coagulated, and dried until a thick deposit of rubber surrounds the large drum. The damper on the centre baffle plate is then shut and the door in the smoke box opened. The rubber on the drum is slit across with a knife and unrolled in a large sheet, which can be cut to any size for packing.

"The antiseptic qualities of the fumes tend to preserve the rubber, and the sheets are treated through and through."

In communication with Mr. Dickson I learned that in this machine there are several doors, which can be opened to let cool air in or regulate the temperature—a most important and essential feature when drying rubber with hot air or fumes. The illustration given elsewhere, shows the general plan of the apparatus.

Another apparatus has been devised in Ceylon to dry the rubber quickly and to coat the freshly coagulated and rolled product with creosote, but has not yet been made public.

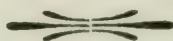
USE OF CALCIUM CHLORIDE.

Mr. Burgess in his lecture already referred to, stated that it was possible to dry rubber quite well and satisfactorily without any artificial heat, by the use of some agent that will dry the air. For this purpose he recommended calcium chloride. This substance is made commercially on a large scale; it is comparatively cheap and very effective as a drying agent. The material as bought is in white granular lumps which, when placed in the open air, absorb moisture from it, and the calcium chloride becomes moist and eventually absorbs so much water that a syrupy liquid results. The great merit of this substance lies in the fact that it can be recovered from the wet state by simply heating and thereby driving off the moisture. A simple form of rubber-drying shed adopted for use with calcium chloride could easily be made with shelves to hold iron pans, in which the calcium chloride could be placed and freely exposed to the air in the chamber. As the calcium chloride absorbs the moisture and becomes sloppy, the pans should be removed and the water driven off over a brisk fire, stirring the mass meanwhile. When quite dry and porous again the pans should be returned to the rubber-drying chamber to do their work again. In this way there would be little or no loss of substance, and the air inside the chamber being constantly dry, mould would be absolutely prevented, and the rubber would dry in half the time. The pans, if used inside the rubber shed, should be placed above the rubber.

“ A still more efficient system would be to devise a circulation of dry air in the chamber, and if this system were adopted it would be best to dry the air before blowing it with fans into the chamber. This could be easily done by causing it to pass over a series of iron pans of calcium chloride contained in a drying box outside.”

A writer in the “India-Rubber Journal” objected to the use of calcium chloride on the ground of expense and the danger of accidental contamination with the rubber, and expressed his opinion that the circulation of dry air was preferable to the use of this chemical. Mr. Ridley, in reply to these objections in the “Straits Bulletin,” stated that in a manufactory on a large scale the calcium chloride would be in pans, well away and above the rubber, and that there would, therefore, be no risk. If calcium chloride is allowed to remain in contact with the rubber it destroys it, but if cleared off immediately it does no harm.

At Peradeniya a series of experiments has been made. A current of dry hot air is made to pass rapidly through a specially constructed chamber in which the rubber is arranged on a number of wooden trays. The air is first dried by passing it through a series of crates or cells containing hygroscopic chemicals. The crates can be easily removed, dried, and replaced. The dry air is then drawn over a fire by means of a fan, the latter being turned by hand or power. By this means the rubber is dried fairly rapidly ; if the temperature is maintained at about 90° F., the rubber is thoroughly dried in a few days if the sheets are not too thick, and softening does not occur if the rubber is not dried too quickly. It is as well to mention that the softening of rubber alone, when due to too rapid drying, is not objected to by manufacturers, as the masticating process, through which the dry rubber passes, converts the material into a substance void of all toughness and elasticity; but any softening of the rubber before it leaves the factory of the producer might prove very serious as the sheets or biscuits would be bound to adhere to one another, and probably become tacky before their arrival in Europe.



CHAPTER XV.

PHYSICAL AND CHEMICAL PROPERTIES OF RUBBER.

Analyses of Para-rubber from Ceylon, Bukit Rajah, Duckwari, Arapolakande, Syston, Lanadron and Hawthorn estates, Penang, Gold Coast and the Straits.—Analyses of plantation samples at Ceylon Rubber Exhibition—Analyses of Ceylon plantation rubber by Schidrowitz and Kaye—Analyses by Bamber of Para rubber from trees of different ages—Analyses of Para, Ceara, Castilloa, Landolphia, Ficus, Urceola and Rhynocodia rubbers compared—Chemical and physical properties of rubber—Empirical chemical analyses and their value—Caoutchouc by difference—Opinions of Dunstan—Relation between the physical properties and chemical composition—Resins—Resins in Para rubber—Resins in rubber from Castilloa, Manihot, Landolphia, Ficus and Hancornia species—Resins in crude rubbers from Uganda, Mexico, Ceylon and Malay by Schidrowitz and Kaye—Removal of resins from rubber—Characters of resin—Resin—Free rubbers—Albuminoids in rubber—Ash constituents in washed rubber—Potassium in washed rubber—The insoluble constituent—Oxygen—Physical properties of india-rubber—Effect of alkalies, acids and halogens—Elasticity, resiliency, colour and odour—Action of heat on rubber

HAVING briefly indicated the composition and characters of the latex as it appears in the factory of the cultivator, the same features in the finished product can now be considered with the object of gaining an insight into the changes which have taken place, and the processes adopted in Europe to extract from the rubber impurities originally present in the latex. The prepared article may be expected to contain all the insoluble components of the latex, except those removed by mechanical operations. The following analyses of plantation rubber, prepared from *Hevea*

brasiliensis in various parts of the world, may be taken as good examples :—

	Ceylon Para Rubber.	Para Rubber from the Bukit Rajah Co., F.M.S.†	Penang Para Rubber.‡	Gold Coast Para Rubber§ A B		Straits || Rubber; old sample.
	per cent.	per cent.	per cent.	per cent.		per cent.
Caoutchouc ..	95·50	95·37	95·00	95·53	95·96	93·22
Resins, &c. ..	3·00	3·02	4·03	3·90	3·25	1·76
Aluminous matter ..	1·25	1·24	—	—	—	4·20
Ash of mineral matters ...		0·25	0·37 0·05	0·18	0·22	0·32
Moisture ..		—	0·15	0·39	0·57	0·50

The sample from Ceylon was valued at 5s. 7½d. per lb., and the report stated that the rubber was free from moisture, very strong, and vulcanized well. The sample from the Bukit Rajah Co. was considered to be very suitable for vulcanization, and sold at a little over 7 francs per pound. The Penang sample was prepared in rectangular cakes, was dark brown in colour, transparent, and contained no mechanical impurities; one piece was sticky. The value was considered to be equal to the current market rate of good Para.

The samples from the Gold Coast were considered to be of excellent quality, free from mechanical impurities, and in February, 1904, were valued at 4s. 6d. to 4s. 7d. per lb. The old sample of Straits rubber had been kept in Ceylon for a considerable length of time.

The high percentage of caoutchouc in Para rubber, grown in different countries, is so far very satisfactory. Johnson has shown that whereas the cultivated Para may contain over 95 per cent. of caoutchouc and less than 4 per cent. of resinous matter, the native African rubber (*Funtumia elastica*) contains less than 90 per cent. of caoutchouc and over 8 per cent. of resinous compounds. From the foregoing analyses and valuations it may safely be asserted that *Hevea brasiliensis* bids fair to beat many rubber trees indigenous to tropical areas. Resins in large quantities, aluminoids, and ash constituents are not required, and in many articles of commerce are injurious.

* Tropical Agriculturist, Vol. XXIV. No. 5, November, 1904.

† Journal d'Agriculture Tropicale, April, 1905.

‡ Agr. Bull. of Straits and F.M.S., April, 1904.

§ Johnson, Report on Rubber in the Gold Coast, 1905.

|| By M. Kelway Bamber.

ANALYSES OF PLANTATION RUBBER.

The following are the analyses by Mr. Kelway Bamber, as published in the Official Handbook, of various rubbers at the Ceylon Exhibition; the first four rubbers were gold medal samples:—

Para Rubber.	Moisture.	Resin.	Ash.	Proteins.	Caoutchouc.
Duckwari biscuits ..	0.68	2.32	0.36	3.00	93.64
Arapolakando smoked biscuits ..	0.28	1.84	0.20	2.12	95.56
Syston sheet ..	0.30	2.74	0.20	2.25	94.51
Lanadron block ..	0.36	2.44	0.20	3.31	93.69
Hawthorn Estate, S. India ..	0.60	3.02	0.40	2.82	93.16
Typical weak sheets ..	1.04	3.34	0.36	2.82	92.44
Typical weak biscuits ..	0.68	2.14	0.24	3.00	93.94
Brazilian Para ..	3.88	2.42	0.30	2.97	90.43

As far as the chemical composition of rubber goes, there seems nothing to account for the differences in the strength of various plantation and other rubbers. The splendid Duckwari biscuits and "typical weak biscuits" show practically no difference in chemical composition, the percentage of moisture and proteins are identical, and the weak rubber contains less ash and less resin and more caoutchouc than the gold medal sample.

Typical weak sheet contains, according to the analyses by Bamber, more moisture than any of the other samples.

The best plantation samples at the Ceylon Rubber Exhibition contained practically no moisture in the majority of cases, there being less than 1 per cent. present, while a typical sample of weak Para sheet contained 1.04 per cent. of moisture.

CEYLON PLANTATION RUBBERS (HEVEA BRASILIENSIS).

	(1)	(2)	(3)
	Very thin biscuit 1/3 to 1/5 mm. in centre to 1 mm. at edges; translucent; light amber colour; edges somewhat darker.	Thin biscuit, from (centre) to 1 mm. (edges); translucent; light amber colour, but a good deal darker in centre, although latter thinner than edges.	Biscuit even thickness of 3 to 4 mm. even amber colour; translucent, some air bubbles.
Moisture ..	per cent. 0.73	per cent. 0.45	per cent. 0.36
Resin ..	1.36	2.42	2.69
Mineral matter ..	0.74	0.69	0.33
"Dirt and* organic impurities" ..	12.52	6.60	2.92
India-rubber ..	84.15	8.84	93.70
Nitrogen ..	0.17	0.60	0.16
Nitrogen as proteids ..	1.06	3.75	1.00
Specific gravity at 15° C.	0.9160	0.9202	0.9097

* By difference.

Messrs. Schidrowitz and Kaye, in the Journal of the Chemical Society, have dealt with the composition of Ceylon biscuits of various thicknesses, and their analyses are given above; other analyses * by the same chemists show that rubber prepared from Ceylon latex possessed from about 86 over 90 per cent. of caoutchouc, when the moisture ranged from 5 to 9 per cent.

SPECIFIC GRAVITY OF RAW AND VULCANIZED RUBBERS.

Messrs. Clayton Beadle and Stevens (Chemical News, Nov. 15th and November 21st., 1907) give several determinations of the specific gravities of rubbers examined by them. They show that the specific gravity of apparently similar biscuits, blocks, etc., may vary according to the method employed in the preparation of rubber, those having a large proportion of air bubbles or which have not been severely pressed being lighter than others.

When dealing with vulcanized rubbers they point out that there is a tendency for the specific gravity to increase on keeping, especially if the samples have been fully cured. Over-cured samples which had been kept for sometime showed high specific gravities; there was usually a loss in tensile strength with a conspicuous increase in specific gravity.

Mr. M. Kelway Bamber has made a series of analyses of Para rubber from trees of different ages, and the proportion of resin is here shown:—

PARA RUBBER FROM TREES OF DIFFERENT AGES.

	Two years.		Four years.		Six	Seven
	A.	B.	A.	B.	years.	years.
Resin ..	3·25%	3·60%	3·28%	2·72%	2·75%	2·10%
	Eight years.		Ten-Twelve years.		Thirty years.	
Resin ..	2·66%		2·26%		2·32%	

PARA AND OTHER RUBBERS.

It has been suggested that the addition of analyses of other rubbers might be of value, and accordingly the following tables have been drawn up:—

Ceylon-grown Para, Ceara, and Castilloa Rubber. (1)

	Para Rubber. per cent.	Ceara Rubber. per cent.	Castilloa Rubber. per cent.
Caoutchouc ..	94·60	76·25	86·19
Resin ..	2·66	10·04	12·42
Proteids ..	1·75	8·05	0·87
Ash ..	0·14	2·46	0·20
Moisture ..	0·85	3·20	0·32

* India-Rubber Journal, 1st July, 1907.

(1) M. Kelway Bamber, Committee of Agricultural Experiments, November, 1905

Para compared with Rubber from Landolphia.

	(2)		(3)		(4)
	Landolphia		Landolphia		Landolphia Watsoniana
	Kirkii.		Petersiana.		(East African rubber).
	per cent.		per cent.		per cent.
Caoutchouc ..	80.1	..	67.7	..	67.2
Resin ..	6.9	..	11.1	..	11.9
Dirt and insoluble matter ..	5.3	..	3.4	..	8.0
Ash included in dirt ..	0.31	..	1.2	..	1.3
Moisture. ..	7.7	..	17.7	..	12.9
	Valued at 4/- per lb. when fine Para 4/8		Valued at 3/- per lb. when Para at 4/10		Valued at 2/3 to 2/4 per lb in 1903.

Para compared with Ficus, Urceola, and Rhynocodia Rubber.

	(5)		(6)		(7)		(8)
	Species of Ficus.		Ficus elastica (Bengal).		Urceola esculenta		Rhynocodia Wallichii.
	per cent.		per cent.		per cent.		per cent.
Caoutchouc ..	19.6	..	84.3	..	80.5	..	86.5
Resin ..	49.9	..	11.8	..	9.8	..	6.5
Dirt and insoluble matter ..	2.1	..	3.1	..	5.7	..	4.2
Ash included in dirt ..	0.79	..	0.8	..	1.16	..	0.48
Moisture ..	28.4	..	0.8	..	4.0	..	2.8
	Valued at 11d. per lb. when Para at 4/8		Valued at 1/10 to 2/1 when Para at 4/8		Valued at 4/- per lb when Para at 4/8		Value 1 at 3/6 per lb. in 1902

CHEMICAL AND PHYSICAL PROPERTIES OF RUBBER.

It has been previously pointed out, in the "India-Rubber Journal," that the physical characters of various oils, gums and resins can generally be associated with differences in chemical composition. A slight change in the proportion of certain chemical ingredients or reduction or oxidation of components in a mixture, often appreciably affects the physical properties of the products under observation. The same may, to a limited extent, be applied to various rubbers which regularly appear on the market. An increase in the percentage of resinous constituents may change the rubber to a brittle or sticky mass, and it is already possible to group some rubbers according to

(2) Bulletin of the Imperial Institute, June, 1904.

(3) Do. do. do. June, 1904 (rubber from Natal).

(4) Do. do. do. Jan., 1905 (rubber from East Africa).

(5-6) Bulletin of Imperial Institute, Sept., 1904 (Rubber from Burma).

(7) Technical Reports and Scientific Papers, Imperial Institute, 1903.

(8) Bulletin of Imperial Institute, Vol. 1, p. 69, 1903.

their chemical composition and associated physical properties. Chemical analyses even as submitted to-day, in their undoubtedly empirical and undesirable form, allow us to sometimes distinguish the botanical sources of certain latices and rubbers, though the plants yielding them may not at the time be available for botanical verification. But no one can deny that the analyses of rubber as at present submitted often give no indication of the physical differences which exist between samples of rubber obtained from Para trees of different ages. This does not necessarily disprove that a correlation exists between the chemical composition and the physical properties of the rubber, but suggests that the analyses do not distinguish the differences between the components of the groups enumerated. We contend that it is not sufficient to merely state the percentage of resinous, albuminous, and caoutchouc contents in samples of rubber; this grouping of most of the constituents and the calculation of caoutchouc by difference does not give us any idea of the differences which we are led to believe exist between the proteins involved in the phases of coagulation and those which appear in solution after the complete separation of the caoutchouc; neither does it give us a clear conception of the differences between the components in each of the other groups or between the individual resins and caoutchouc globules in trees of different ages, and in the latex from different species.

Professor Dunstan, in his address before the British Association in 1906, pointed out that the chemical analysis of raw rubber as at present conducted is not always to be taken by itself as a trustworthy criterion of quality and more refined processes of analysis are now needed. In a recent Bulletin of the Imperial Institute the Director again emphasises this point. He states that, "at present the caoutchouc is usually determined by difference" from the results of the direct determination of the other constituents. All the errors of the analysis are therefore concentrated in the stated percentage of caoutchouc, whilst in the absence of an accurate direct determination of the caoutchouc the homogeneity of this constituent in different samples of crude rubber and in rubbers of different origin has to be assumed. The physical characters of rubber are still more roughly determined by the manual tests of brokers, and precise methods of determining strength and resiliency are much needed."

It is, however, the opinion of many that though the chemical composition of rubber may exhibit considerable variation the physical properties of raw rubber can often be correlated with them. The elastic caoutchouc in the various rubbers is of a very similar chemical structure and the same may be said of some of the ingredients of raw rubber which have already been isolated.

RESINS.

In Para rubber the amount of resinous and oily substances varies from 1 to 4 per cent., when obtained from mature trees. Many analyses have been made of rubber from trees of various ages and of different species. In the case of *Castilloa elastica*, Weber* proved that not only does the percentage of resin decrease with the age, but that it increases as one passes to younger parts of the same tree. His figures were as follows:—

Resins in Rubber of Castilloa Trees.

From	Per cent.
Trunk	2.61
Largest branches	3.77
Medium	4.88
Young	5.86
Leaves	7.50

A similar increase in resin in the rubber from young *Castilloa* trees of different ages was also described, the variation being from 7.21 per cent. from eight-year-old trees to 35.02 in rubber from trees three years old.

Weber concluded that it could scarcely be doubted that rubber from other kinds of rubber trees would exhibit similar relationships; subsequent research has not confirmed this contention as far as Para rubber is concerned.

RESINS IN VARIOUS RUBBER.

The following percentages of resins in various rubbers are given by Weber:—

	Per cent.
Para (<i>Hevea brasiliensis</i>)	1.3
Ceara (<i>Manihot Glaziovii</i>)	2.1
Colombie (<i>Castilloa elastica</i>)	3.8
Madagascar (<i>Landolphia?</i>)	8.2
Assam (<i>Ficus elastica</i>)	11.3
Mangabeira (<i>Hancornia species</i>)	13.1
African balls (<i>Landolphia?</i>)	27.8

Messrs. Schidrowitz and Kaye † in their note on the resins in various crude rubbers examined by them give some figures which they have obtained for the total alkali absorbed by the resins in the rubbers described above. "The results are expressed in c. c. N. 10 alkali required to fully neutralize and saponify 1 gm. of the resin in each case.

* Weber, India Rubber and Gutta Percha Trades Journal, Sept. 29, 1902.

† India-Rubber Journal, April 8th, 1907.

The following figures were obtained:—

		1.		2.		3.
Uganda	..	8.83	..	6.70	..	—
Mexican	..	16.61	..	—	..	—
Ceylon	..	6.03	..	27.03	..	30.2
Malay	..	17.54	..	3.21	..	12.70

The low figures in the case of Ceylon No. 1, which was appreciably different from the other samples, and in the case of Malay No. 2, which was coagulated by nitric acid, are worthy of note; otherwise the figures for the various groups of rubbers are fairly comparable."

The figures relate to the quantity of alkali required to fully neutralize and saponify the resins in the various rubbers. The resins are a highly complex class of bodies consisting as a rule, of a mixture of various constituents; different resins behave in different ways and their condition as well as quantity are of importance. It is possible that some resins are not only not disadvantageous, but possibly of advantage up to a certain point.

REMOVAL OF RESINS FROM RUBBER.

The resin content of crude rubber is a subject which has occupied the attention of numerous chemists, owing to the importance of this substance in the vulcanised product.

The amount of resin in various samples of rubber varies considerably in some cases, even in different samples known under the same name the quantity may vary quite 50 per cent. As to the value of rubber freed from resin, opinions are somewhat at variance. The Rheinisher Gummiwerke—(cf. India-Rubber Journal, February 1907)—claim to be able to place on the market a rubber which for all technical purposes may be considered free from resin. An examination of these resin-free rubbers has been made by Drs. Frank, Marekwald and Leebshuetz with the object of determining whether the extraction of the resins from raw-washed rubber influences the manufacturing process favourably or unfavourably. They report that the sheets of rubber obtained in the ordinary way from the extracted rubber are in every case less sticky and more uniform than those from non-extracted material. Further the extracted rubber was described as being brighter in appearance and the smell characteristic of the several brands had invariably disappeared. Physical tests were also made both with the extracted and non-extracted rubbers. Various brands of upper Congo, Madagascar and Gambia rubbers were employed for these determinations, containing varying amounts of resin, ranging from 4 to 38 $\frac{1}{2}$ %, which after extraction were reduced from 2 to 9%.

As a result of their experiments on the rubbers from which the greater part of the resins had been extracted, they concluded as follows:—

- (1). The specific smell of the raw material is removed.
- (2). Its stickiness also disappears completely by extraction of the resins, thus materially assisting mixing operations.
- (3). The solidity of vulcanized goods made from extracted rubbers of typical bad qualities is invariably greatly superior, being sometimes as much as 50 per cent. better than the non-extracted rubber.
- (4). The extraction of resin facilitates uniform qualities being supplied.

The removal of resins from rubbers in this way is of more interest to those planters concerned with Para rubber in the wild state or with other American and African rubbers containing large proportions of resinous contents. It is, however, a subject of interest to all rubber growers as besides producing the advantages already mentioned it would effect a reduction in cost of transport and be of importance to the manufacturer. Pure plantation rubbers containing less than 4 per cent. of resin would, however, not require such treatment

Though the various "Plantation" and "Wild" rubbers which arrive in Europe contain resin in quantities varying from 1 to about 40 per cent., they appear to be all subjected to the same process in the attempt to extract this ingredient. According to Weber,* the resins can be removed by extracting with acetone in a Soxhlet extractor, the highly porous washed sheets of rubber lending themselves best to this purification process. The complete extraction of these resins from rubber requires many days. The presence of the resinous impurities influences the behaviour of the rubber in practical working and also the stability of the finished article. Owing to the supposed detrimental effect of the resins after vulcanization, no efforts are spared to reduce them to the desired quantity in the inferior brands of rubber. The extraction of some of the resinous bodies from the latex of certain plants is a subject which, though crowded with difficulties, might profitably engage the time of the producer in the Tropics.

ALBUMINOIDS.

The albuminoids, which either alone or with other substances lead to putrefaction, exist almost entirely in solution in the fresh latex. Their removal from commercial rubber on a large scale is considered by many to be almost impossible.

* Weber, l.c., p. 3.

Weber suggested that an expeditious method would be to centrifugalize the solutions, a method which has been dealt with when describing the machines used in preparing and purifying rubber.

The addition of formaldehyde to some latices is supposed (1) to prevent the coagulation of the albumen and (2) to cause the india-rubber to collect on the top of the mixture. The proper application of this reagent to Castilleja latex is said to free the rubber from every trace of albuminous matter. It has, however, been questioned whether, or not, the caoutchouc would coagulate or even coalesce, if all albuminoids were removed from the latex.

There is a slightly higher percentage of proteins and resins in Para rubber from young than in that from old plants, the poor physical properties of young plantation rubber may be ultimately associated with the proportion of these constituents present in the samples.

ASH.

This impurity is present in almost negligible quantities—0.18 to 0.5 per cent. Generally, Para rubber contains 0.3 per cent. of ash, as against 0.2 per cent. in other rubbers. Weber is responsible for the statement "that it may yet be possible to chemically identify the brand of india-rubber from ash analyses." Lime is said to predominate in Para rubber, magnesia in Ceara, and ferrous oxide in African rubbers. The presence of the ash impurities is undesirable on account of their tendency to interfuse with the india-rubber and the resinous constituents during the processes of manufacture.

Spence, as a result of his analyses* of Funtumia rubber, concludes that the ash in a sample of washed rubber is remarkably constant in quantity and supports Weber's suggestion that the ash contents might be employed, when exhaustive investigation of the quantitative composition of the ash of the various brands has been made, as a chemical method of distinguishing washed rubber from different sources. The constancy of the mineral constituents in washed rubber is a point of considerable importance.

POTASSIUM IN WASHED RUBBER.

Spence in his concluding paragraph states "that the percentage of potassium salts to be found in a sample of washed rubber from *Funtumia elastica* may be taken as an indication of the purity of the rubber and the efficiency of the washing process". Whether the same applies to washed Pararubber has not yet been stated by chemists.

Potassium, though it is the chief mineral constituent in the ash from the latex, disappears from the coagulated rubber in the process

* India-Rubber Journal, September, 1907.

of washing. In a sample of *Funtumia elastica* latex it was present in the form of soluble salts of inorganic and organic acids and composed about 75 per cent. of the ash of the latex on incineration, according to Spence.

The insoluble constituent present in rubber is a substance which is free from stickiness, is remarkably tough, and has moderate distensibility. Its nature and importance is imperfectly understood.

There is a quantity of oxygen present in india-rubber, but the proportion of this is, according to Weber, reduced practically to vanishing point in successive purifying processes.

GENERAL PROPERTIES OF INDIARUBBER.

Alkalies have not a pronounced action upon indiarubber at low temperatures. Heinzerling states that on prolonged digestion with ammonia the indiarubber passes into the state of an emulsion, in appearance closely resembling india-rubber milk.

The effect of chlorine, bromine, and iodine on indiarubber is very complicated, and for a full knowledge of the various changes which are induced by their action reference must be made to Weber (pp. 31-37). Acids exert a strong action on india-rubber articles commonly used. Strong sulphuric acid oxidises rubber; strong nitric acid attacks rubber vigorously, forming at first a yellow compound which is subsequently decomposed. The effect of oxygen on crude and vulcanized rubber is to cause deterioration, a compound known as Spiller's resin being formed. Crude indiarubber, particularly just after it leaves the washing machine for the drying room, is apt to suffer considerably from oxidation during the drying process, and it seems possible that similar changes may occur after coagulation and pressing in the tropics.

Though india-rubber is insoluble in water, it rapidly swells when immersed in it and absorbs a considerable amount of the liquid, the actual amount capable of being absorbed increasing with a decrease in the resin and oily substances. On this account the rubber from young trees may perhaps be roughly detected by the water capacity of the sample of rubber, allowing for normal variations. When vulcanized the water absorption power of indiarubber is small. Though india-rubber does not readily react with many common reagents, it does to a surprising degree with sulphur in its various forms, the process of combination being commonly spoken of as vulcanization. Pure sulphur does not combine with india-rubber at temperatures below 270°F., but sulphur mono-chloride readily reacts with it at ordinary temperatures.

The elasticity, resiliency, colour, and odour of rubber vary considerably, according to the age of the trees, and the methods of collecting, coagulating, and curing the product. Rubber from

mature trees, if well prepared, is of a pale amber colour, has a slight odour, and is very tough; badly-prepared rubber or that from young trees is frequently speckled, emits a foul odour, and may on keeping become sticky, plastic, or brittle.

ACTION OF HEAT ON INDIA-RUBBER.

India-rubber becomes sticky if subjected to high temperatures. It passes into quite a liquid state at ordinary temperatures under certain conditions; if sound rubber is subjected to 170 to 180°C., it becomes more or less fluid. The melting point, if rubber can be said to have one, is much higher than this if the resin has been extracted. It is important that all drying and coagulating processes should be so devised as to ensure the temperature being regulated, and a maximum temperature considerably below that just quoted should be guaranteed.

India-rubber articles, if exposed to high temperatures, are apt to lose their strength, and to* develop either sticky or brittle properties.



CHAPTER XVI.

PURIFICATION OF RUBBER.

Analyses of washed and dried Para rubber—Purification by the manufacturers—Lawrence's process for cleaning crude rubbers—Loss in the manufacture of brands of Para rubber—Loss on washing rubber—Oily and resinous substances and ash in various rubbers—High loss undesirable—Purification of plantation rubber—Description of rubber washing machine—The machine at work—Washing scrap and dirty rubber—General account of washing machines—Steam-jacketed rollers—The cut of rollers—Illustrations showing various types of rubber machinery and rollers of different patterns—Macerators for bark shavings—Characters of washed rubber—Rapid washing and drying

HAVING dealt with the properties of the latex and the various methods of preparing rubber therefrom, it is now necessary to consider the important question of the condition of the rubber when it enters the market, and the processes through which it passes in purification. It is possible that much time and trouble may be saved, and at the same time a rubber of higher quality be produced, by carrying out certain purification processes in the initial stages. The condition of the rubber when it arrives in Europe is well-known to most cultivators, as it undergoes no changes during transit if it has been properly prepared. An ordinary sample of washed and dried fine Para rubber may contain the following:—

Rubber	..	..	94·0 per cent
Resinous matter	..	..	2·5 „
Albuminous matter	..	..	3·0 „
Mineral matter	..	..	0·5 „

Very often grades of washed rubber, prepared carelessly, contain nearly 20 per cent. of impurities, and in the case of “scrap” rubber the question of purification may become a serious one.

PURIFICATION BY THE MANUFACTURERS.

The scraps of fibre, particles of sand, abundance of resins, albuminoids, and mineral matter are not required in the finished product, and the mechanical and soluble impurities are, as far as pos-

sible removed by the manufacturer. In Europe the rubber is first cut into small pieces and placed in tanks containing hot or boiling water. It is then put through the washing machines, the rollers of which tear, cut, and expose all parts of it to a current of clean water. The success of this method depends upon the rubber being cut into sufficiently small pieces and soaked for the proper length of time in water maintained at the desired temperature. The washing process removes every kind of mechanical impurity, the fragments of fibre, sand, &c., flying out of the softened rubber when it is stretched and torn between the rollers. These impurities are loosely embedded in the rubber, but if the temperature is raised too high the resins may be converted into sticky substances, which will cement the rubber and mechanical impurities and thus render it impossible to remove the latter by this process.

The fragments rejoin and finally form a porous sheet which, when dry, is known as washed rubber to the manufacturer. The rubber may then undergo various masticating, mixing, and vulcanizing processes.

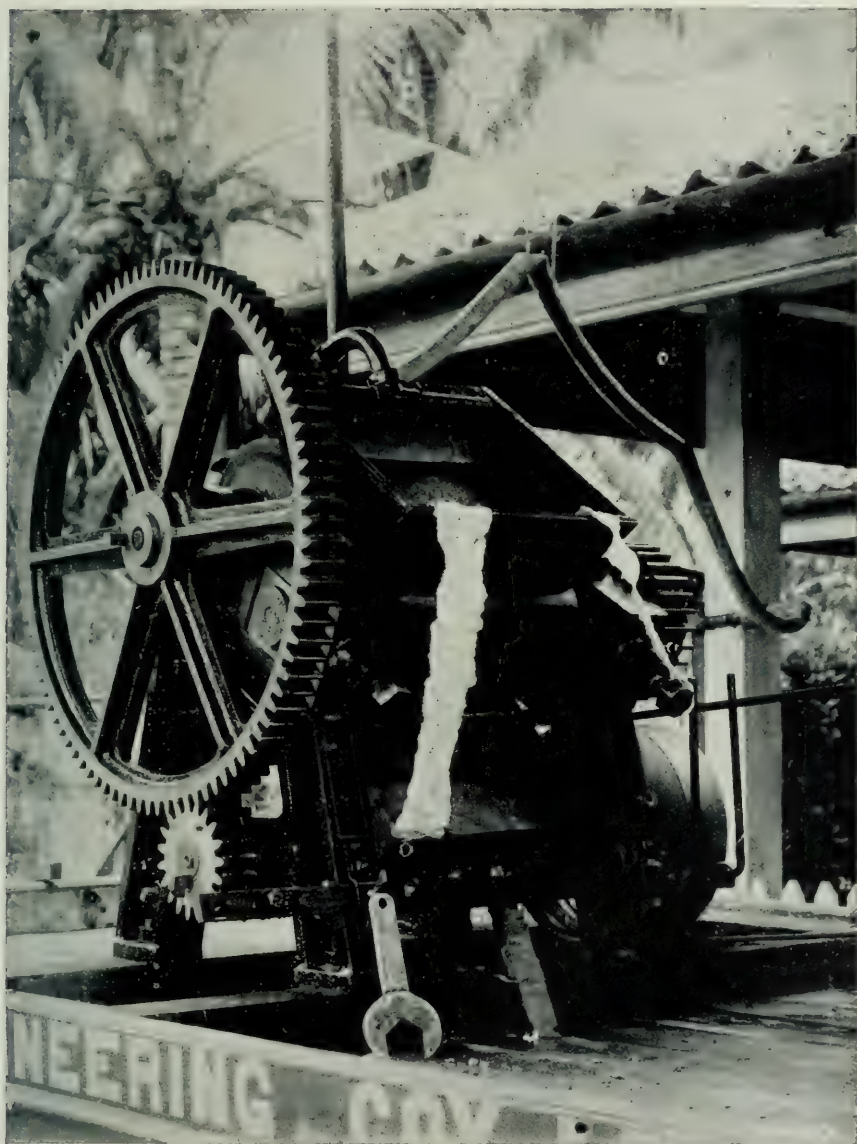
Lawrence has, according to the "India-Rubber Journal," November 20, 1905, brought out a patent method for cleaning crude rubber, which is to some extent applicable to ordinary scrap rubber on estates. The process consists of first grinding or macerating the rubber, and then subjecting it to liquids or solutions having different specific gravities. It is specially devised to deal with the extraction of the fibrous and woody matter in crude or scrap rubber.

LOSS IN MANUFACTURING.

The actual loss in these purification processes is often surprising. The loss on washing some of the Para rubber collected by the natives in the Amazon District varies from 10 to 40 per cent. Biffen states that the loss in the factories is as follows for different grades of Para rubber :—(1) fine Para, 10-15 per cent. ; (2) extra fine, the carelessly smoked pieces, 15-20 per cent.; Sernamby, rubber pulled from the cuts on the tree and cups, 20-40 per cent. Many lots of fine wild Para have, during recent times,* shown a loss on washing of from 15-16 per cent. in samples containing 2·2 to 2·9 per cent. of resin and 0·27 to 0·29 per cent. of ash. According to Johnson, the loss from fine Para is from 10-15 per cent., whereas that from the plantation biscuit, sheet, crêpe, &c., rubber is only about 1 per cent. Weber† states that the fine Para rubber from the Amazon District shows a loss on washing of 12 to 18 per cent., and contains 1·3 per cent. of resin and 0·3 per cent. of ash in the dry washed material.

* India-Rubber Journal, April 28, 1902.

† Weber, *l.c.*, p. 122.



Federated Engineering Co.
A RUBBER WASHING MACHINE.
A
SHOWING WATER PIPES AND CREPE RUBBER.

Different brands show a variation in the amount of the loss on washing as indicated below, and the composition of the impurities are clearly put forward by Weber:—

Brand.	Loss on Washing, per cent.	Oily and Resinous Substances, per cent.	Ash, per cent.
Ceylon ..	1	3.0	0.5
Para, hard cure ..	15	2.1	0.5
Para, soft cure ..	17	2.5	0.3
Ceara ..	32	2.0	2.74
Borneo ..	48	2.2	2.2

The loss on washing is estimated by determining the yield of dry washed rubber obtainable from a known bulk of crude rubber. This loss consists mainly of water, salts, wood fibres, and mineral impurities. The oily substances form a very small part only of the total extract. Weber states that the resinous matter is generally semi-transparent, yellowish-brown, or brown; in some cases it is semi-resilient and slightly sticky, sometimes hard and brittle, and in a few cases is white and powdery in appearance. The estimation of these oily and resinous constituents is best carried out by extracting 5 to 10 grammes of the perfectly dry washed rubber in a Soxhlet extractor by means of acetone. Many persons assume that the percentage of resinous matter in indiarubber is an indication of the care bestowed upon it by the producer. This is not correct, as the resinous matters exist in the latex as the latter flows from the trees. The variation in the resin of the same brand of rubber is probably due to the condition or age of the tree from which the latex is obtained, or to the mixing of milks of different qualities.

HIGH LOSS UNDESIRABLE.

If the loss on washing is beyond a certain amount the rubber will be naturally classed as inferior. In a paper* read before the International Congress of Applied Chemistry the following interesting passage occurs:—"While fifteen years ago, fine Para rarely showed a loss in washing exceeding from 10 to 12 per cent., this rose within the last ten years from 12 to 16 per cent., and in the last five years had reached from 15 to 20 per cent. During the same time Colombia Virgin, at one time one of the finest brands of rubber, has practically entirely disappeared from the market. What little still occurs under the name is an altogether inferior product."

PURIFICATION BY THE GROWERS.

The use of machinery is bound to become more general when more rubber is collected; the means adopted for straining,

* India-Rubber Journal, July 20.

purifying, and coagulating the latex will minimise the loss which normally occurs in the manufacturing process. Already machines for washing the rubber by the grower have been strongly recommended by authorities in the East.

RUBBER WASHING MACHINE.

In rubber districts a modified wringing machine is frequently used, which, though it is light and cheap, cannot usually be recommended as efficient. If a sufficiently powerful and well-equipped rubber washing machine is used, the effect is not only to free the rubber from a large proportion of the soluble impurities, but to produce a dried product possessing good physical properties

A RUBBER WASHING MACHINE.

The following is Mr. P. J. Burgess's account of the new rubber washing machine :—

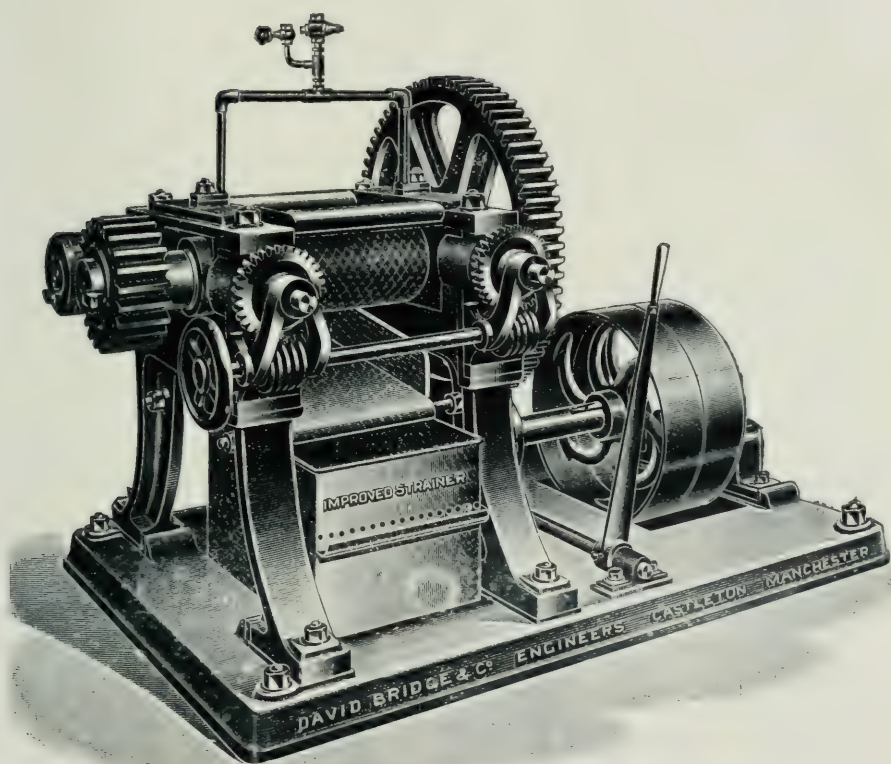
“This machine consists essentially of two steel rollers, which revolve on horizontal axes parallel to one another; the distance between the surfaces of the two rollers can be adjusted, and varies from $\frac{3}{4}$ inch to practical contact.

‘The rollers revolve at different speeds and are driven by power transmitted from belt and pulley through gear wheels to the rollers themselves.

“The axes of the two rollers may be on the same horizontal plane, more usually one is slightly above the other; a stream of water flows over the surface of the rollers all the time they are in use.

THE MACHINE AT WORK.

“When the machine is used, freshly-coagulated lumps of rubber are put between the rollers, which are separated about $\frac{1}{4}$ inch. The rubber is passed through several times, the rollers being gradually approximated to each other, and the rubber becomes compacted and to some degree hardened. At the same time the effect of the differential rate of movement of the two roller surfaces is to subject the rubber to a shearing stress, which stretches and tears it to pieces, and it is here that the peculiar property of rubber is clearly seen. The elastic stretching and rebound kick out any gross mechanical impurity that may be present, and when the machine is used on scrap rubber there is a perfect shower of dirt, pieces of bark and wood being thrown out from the front of the machine. Freshly-cut or torn surfaces of rubber reunite on contact and pressure; for this reason the fragments, into which the rubber is torn by the machine, reunite and emerge as a continuous sheet. At the same time the stream of water thoroughly washes out any impurity soluble in water that may be left in the rubber. The final product is a coherent



HEAVY WASHING MILL.

but granular sheet of rubber, the thickness of which can be regulated by the distance left between the rollers. The function of the machine is thus three-fold. :—

“1.—It ejects mechanically any solid impurity.

“2.—It breaks up the rubber, and subjects all portions of it to the washing effect of flowing water.

“3.—It produces a granular thin sheet of uniform thickness, which is clean and which can be easily and rapidly dried.

“The interests at stake are so great that I may be permitted perhaps to put in condensed form the advantages of the use of a washing machine in preparing rubber.—

“1.—The rubber produced will be as pure as it possibly can be without costly chemical treatment.

“2.—The rubber, being pure, will be of uniform quality.

“3.—The rubber, being washed, will be ready for immediate use by the manufacturer.

“4.—It will effect a saving of labour to the planter by eliminating the petty hand labour involved in preparing rubber in small plates, rolling the sheets by hand, and manipulation of the small biscuits.

“5.—There will be an enormous saving of time in drying the rubber; this will involve a saving of storage room and labour in looking after the rubber when drying.

“6.—There will be no possibility of putrefaction of rubber in drying, or discolouration by the growth of mould, the substances which putrefy or which feed mould being to some extent eliminated.

“7.—The machines will clean and deal efficiently and economically with scrap.

“8.—The washed rubber can be turned out of any length or thickness required, and will be easier to handle and pack. It keeps better than the best of the biscuits prepared in the old way.”

WASHING SCRAP AND DIRTY RUBBER.

“But the use of a washing machine driven by an engine is not by any means confined to freshly-coagulated latex. In dealing with scrap and dirty rubber its efficiency is very marked. The scrap is cleaned, mechanical impurities are ejected, dirt and mud are washed away, and the scrap is finally turned out in a form precisely similar to that taken by the first-class rubber, and in a state of purity which is only a trifle inferior to it. With rubber from *Ficus elastica* or Rambong the machine deals in a similar manner,

and an easy and simple method of treatment of this hitherto intractable latex is made possible. Great difficulty has been found in dealing with Rambong up to the present, because it cannot be coagulated in sheets in the same way as can Para rubber. If, however, the thick latex be churned, beaten, or violently shaken it coagulates in a great lump, and to treat this lump in the old way, to dry and render it fit for export, has been a matter of great difficulty and of many months. The lumps may be treated at once with the washing machine and thin sheets produced, which are clean and which rapidly dry without difficulty."

Since Burgess published the above several firms have brought forward machines of various types, but the lecture by Burgess was one of the first of its kind and the lengthy extracts are, for that reason, here used

GENERAL ACCOUNT OF WASHING MACHINES.

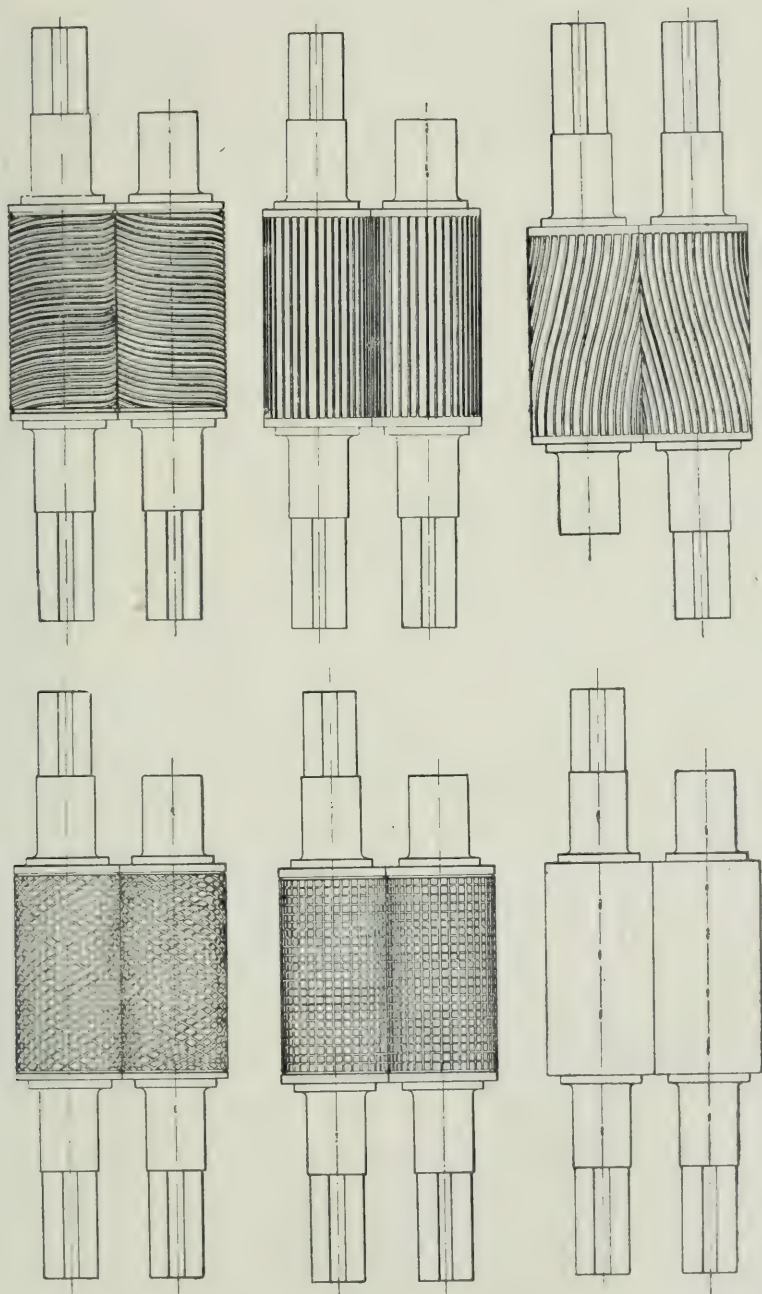
The various washing machines on the market are constructed on somewhat similar principles; they consist essentially of two revolving rollers geared to run at different rates and are so arranged as to allow a good current of water to flow between the rollers when the rubber is being washed. The rollers are usually adjustable to enable the cooly to accommodate a given thickness of rubber; a large machine should be capable of turning out 100 lb. of rubber per hour.

The surfaces of the rollers vary considerably, the majority of those used for freshly-coagulated rubber having comparatively shallow grooves. The rollers through which the soft, spongy rubber first passes are usually diamond, square, or straight cut, the indents always being relatively shallow; the final rollers through which the stretched and washed rubber is passed are usually smooth. Spirally cut rollers are rarely used for freshly-coagulated rubber on plantations, though manufacturers use them for purifying the raw rubber on arrival, at the factory. The accompanying illustration, showing plain, diamond, square, screw, straight and spiral cut rollers, has been kindly lent by Messrs. David Bridge and Co.,

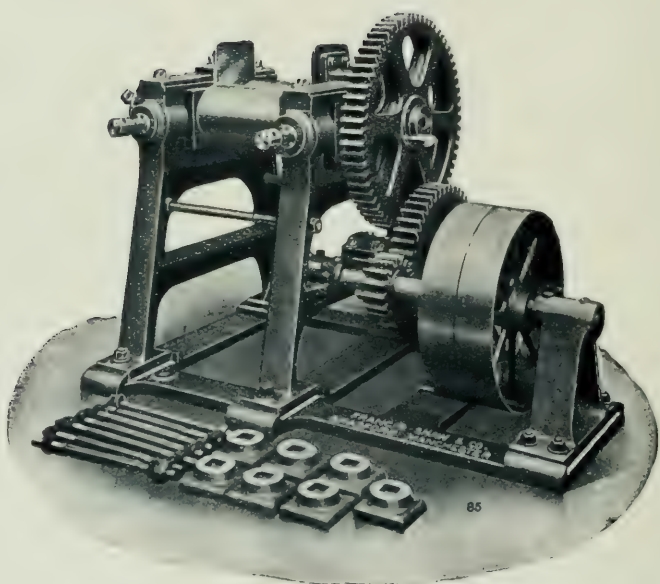
Most rollers are solid and cold; some steam-jacketed rollers have, however, been recently placed on the market by Messrs. Robert Warner & Co., London; these heated rollers make the rubber very soft and turn out material which can be easily blocked.

MACERATORS FOR BARK SHAVINGS.

Bark shavings are usually mixed with varying quantities of scrap rubber, and in addition, contain rubber which has coagulated internally. To macerate the bark tissues and enable the operator to effectively separate the rubber therefrom, a



BRIDGE'S TYPES OF ROLLERS.



SHAW'S RUBBER WASHING MACHINE.

washing machine provided with a pair of spirally cut rollers is usually employed. The bark shavings are usually first steeped in tubs of water for several days in order to soften the tissues; the bark may be more rapidly destroyed by the use of small quantities of caustic alkalis. Before rubber can be effectively separated from the shavings it is generally necessary to pass the whole mass through the rollers many times; the rubber finally obtained from bark shavings is generally dark in colour, and, even though it may have been well washed, has a tendency to becoming sticky on the surface.

In April, 1908, I saw some horizontally-fluted rollers, made by Robinson & Co., Salford, effectively purifying scrap rubber on Culloden estate.

CHARACTERS OF WASHED RUBBER.

If the washing process has been properly carried out the rubber should dry rapidly and give a pale amber-coloured final product. The unevenness depends upon the cut of the rollers and the number of times the rubber has been operated upon; often the rubber has been torn and stretched beyond all requirements. Thoroughly washed rubber does not usually show any signs of mould or tackiness; crêpe—probably on account of the washing to which it has been subjected—is rarely known to arrive in Europe in a mouldy condition; this cannot be said of most other forms. Where machinery is defective the strips of crêpe may have dirty or oily patches which disfigure the consignment; these defects can, however, be remedied.

RAPID WASHING AND DRYING.

The question of rapid washing and drying is one of the most serious with which large rubber growers have to contend. The preparation of small quantities of rubber by the "setting pan" method, and drying in spacious chambers, is not applicable to large estates. It would appear advisable to collect the latex in large tanks until a sufficiently large quantity has been obtained, coagulation being prevented by the addition of reagents; the large quantity of latex can then be rapidly coagulated, and the fresh rubber put through a washing machine, which will turn the rubber out in such a condition that it can be properly cured in two or three days. I am indebted to Messrs. David Bridge & Co., Francis Shaw & Co., and the Federated Engineering Co., for illustrations showing the types of washing machinery commonly supplied.

CHAPTER XVII.

VULCANIZATION AND USES OF RUBBER

Vulcanization of rubber—Heat, sulphur, and india-rubber—The heat cure and cold cure—The Effects of resins upon vulcanization of rubber—Low percentage of resin in Para rubber—The problem of using latex direct—Hancock's experiments—Colouring latex—Sulphurising latex—Bamber's experiments, difficulties on estates and in factories and commercial value—Sulphurising freshly coagulated rubber undesirable—Quantity of india-rubber in common articles, roller covering, steam packing, tyre cover, tobacco pouch, garden hose—The composition of rubber tyres—Analyses by Schidrowitz and Kaye, showing percentage of india-rubber and substitutes—Analyses by Beadle and Stevens, showing composition of solid tyres—Uses of rubber—Purposes for which plantation rubber is useful and useless—The direct use of plantation rubber—Tests with vulcanized plantation rubber—Important results by Beadle and Stevens—Synthetic rubber—Its non-existence—Misuse of the term "Synthetic rubber"—Artificial rubbers, their general characters and uses—Composition of artificial rubber—Improvement of low-grade rubbers—Substitutes for rubber—Use of vulcanized linseed, rape, poppy seed, cotton seed and castor oils—Disuse of rubber.

A GREAT part of the rubber industry is dependent upon the material being in a vulcanized condition, the change being effected by mixing sulphur in one of its many forms with the masticated rubber and then heating the mixture. Usually only from 4 to 5 per cent. of sulphur is used in ordinary vulcanization, but in the production of ebonite or vulcanite as much as 20 to 40 per cent. of sulphur may be used. A more complete distribution of sulphur through the india-rubber may be possible if a solution containing sulphur be added to the latex before coagulation. Prismatic sulphur is readily soluble in carbon bisulphide, benzene, ether, &c.; solutions may be made with any of these and other reagents containing varying amounts of sulphur.

The main factor upon which the action between sulphur and india-rubber depends is heat; there is no action between the two constituents until the temperature is equal to or above that of boiling water; in Europe a temperature varying from 125° to over 300° C. is commonly used in the process of vulcanization. If alkaline polysulphides are used, vulcanization can be effected at temperatures little above 100° C.

In this process a great part of the sulphur becomes fixed by the india-rubber, but not the whole of it ; there is always a certain quantity of sulphur in a free state in vulcanized articles of commerce. Ordinary sulphur, or various compounds of sulphur, may be used in this process, and the articles manufactured from such material are usually considered to be tougher, more resistant, and less easily melted.

THE HEAT AND COLD CURES.

Rubber may be vulcanized either by what is known as the heat cure or the cold cure. In the heat cure the rubber and sulphur are mixed together by machinery and the temperature raised to 300° F., when chemical union takes place between the components, and vulcanized rubber is formed. The whole of the sulphur does not combine with the india-rubber, but if the high temperature is maintained for a long period, more and more of the free sulphur enters into combination and produces a darker and tougher vulcanized product. Though most of the rubber is vulcanized by the above process, the cold cure, dependent upon the action of sulphur components in the cold, is often adopted. In the cold cure, diluted sulphur monochloride is mixed with the rubber, with which it readily combines at ordinary temperatures, and produces a vulcanized product suitable for the manufacture of goods which would be damaged by high temperatures. Sulphur monochloride is a liquid at ordinary temperatures, and on account of its violent action with india-rubber is diluted by dissolving in carbon bisulphide before being used for vulcanizing.

THE EFFECTS OF RESINS UPON VULCANIZATION OF RUBBER.

The presence of resins in Plantation and wild Para and other rubbers has an important bearing upon the reactions that take place during vulcanization. According to the "India-Rubber Journal" of August 13th., 1906, Dr. R. Ditmar has made a careful comparison of several brands of rubber, and communicated the results of his observations to the "Gummi Zeitung." The amount of resin contained in each sample having been first determined, 10 gram lots of the various brands were vulcanized with 10 per cent. of sulphur at 145 deg. C., under a pressure of 3-4 atmospheres, for one hour, and then tested for elasticity and tensile strength. It was found that fine Para, containing 1.44 per cent. of resin, was completely vulcanized and was very elastic. It was only surpassed in the latter respect by Mozambique balls and spindles, Massai balls, and Ceylon Para. The behaviour of the Mozambique balls was remarkable, for although it was considerably richer in resins and was not fully vulcanized, it showed a greater elasticity and strength than the Para rubber with only 1.44 per cent. of resin. The cause of this is probably to be sought more in the origin of the rubber than in the resin it contained. The same properties

were also observed in Adeli balls, Lewa rubber, and Soudan twists, although they did not contain such a high percentage of resin as the Mozambique balls. It is therefore concluded from these experiments that as long as the amount of resin does not exceed 7 per cent. it does not have an injurious effect upon vulcanization, but when over this amount it tends to prevent complete vulcanization of the rubber; at the same time the origin of the rubber is also of great importance in this respect. More accurate information on this subject, however, would be obtained by vulcanizing Para rubber, for instance, with increasing amounts of resin extracted from one quality of rubber. Accordingly, experiments were eventually carried out in the following way; Para rubber containing 3.28 per cent. of resin was well washed and dried, mixed in five gram lots with 10 per cent. of sulphur, and worked up with increasing quantities of Congo resin, extracted from finest black Upper Congo rubber with acetone. Ten such samples were vulcanized for 45 minutes at 145 deg. C., under a pressure of 4.5 atmospheres, then dried, and subjected to physical tests. With the proportion of added resin rising from 3.30 per cent., the breaking strain fell from 9 kilos to 3, whilst the extensibility of the rubber rose from 3.9 to 5.7. The first five samples (3.15 per cent. added resin) were well vulcanized, the remainder were vulcanized throughout, but became gradually softer as the proportion of resin increased.

The percentage of resins in Plantation and Wild Para is, however, usually much smaller than in many of the other rubbers here mentioned and the injurious effect of excess of resins may, as far as Para rubber cultivators are concerned, be dismissed.

USING LATEX DIRECT.

Many attempts have been made to use the latex direct, or after treatment with sulphur solution, in the preparation of rubber articles. Large quantities of latex have been sent to Europe from Africa, Brazil and the Indo-Malayan region and though it appears to have arrived in a satisfactory state, but little advance has been made in this line of research. Hancock * so far back as 1825 patented a process for the manufacture of certain ropes by treating the surface of the fibres with latex which, on coagulation, formed a waterproof, elastic, and durable covering; at a later date he also invented a process of mixing the latex with a fibrous compound made by mixing hair, wool, cotton, etc. to which certain substances, such as whiting, ochre, brickdust, emery powder, were added according to requirements. As the result of his labours Hancock finally decided not to make any further efforts in connection with the utilisation of latex direct, mainly owing to the difficulties he

* India-Rubber Journal, Oct. 8th, 1906.

experienced in obtaining it in sufficiently large quantities and in good condition. In his summing up he states that:— "although rubber in this state would be very useful, and many things could be done with it which are hardly practicable with the solutions, yet the loss of weight by evaporation being nearly two-thirds of the whole, the expense of vessels and the freight of so much worthless matter will probably prevent its ever being used extensively. Before the difficulty of dissolving ordinary rubber was overcome it was thought that the liquid, if it could be obtained, would be invaluable; but now, all things considered, the dry material for nearly all the purposes of manufacture, is the cheapest and most easily applied, although to persons unacquainted with practical details this may appear enigmatical.

Bamber has, in a somewhat similar manner, made samples of rubber belting, flooring, mats, etc., by using sulphurised latex in conjunction with waste coir dust and coconut fibre. The dust and fibre are cheap and obtainable in large quantities in Ceylon and the latex required is very small. When these are thoroughly mixed and combined with sulphur, the mass dried and vulcanised, a strong, hard, and pliable article is said to be obtained.

COLOURING LATEX.

The latex can also be coloured by organic* dyes, such as methylene blue, etc., and the poisonous colouring matter be thoroughly mixed with the rubber instead of being put on the outside as is so often done in the manufacture of childrens' toys. It is interesting to note that though Hancock pointed this principle out in 1857, the method has not been taken up on commercial lines in any of the countries where rubber plants are cultivated. Among the more notable colouring substances used by rubber manufacturers are vermilion, lithopone, golden sulphide, red and brown oxides, zinc white and others, many of which contain combined sulphur.

SULPHURISING LATEX.

The subject of the treatment of the latex, with solutions which will precipitate large quantities of free sulphur in a fine state of division, is one which has been much ventilated during recent times. In the process outlined by Bamber, † a solution of sulphur is added to the fresh latex and thoroughly stirred: on treatment with acid sulphur is precipitated and the latex coagulated, the resultant rubber being minutely permeated with the finely divided particles of sulphur. Antimony solution and the sulphur may, according to Bamber, have a strong antiseptic effect on the rubber. The complete mixing of sulphur with the latex while the latter is in a

* Tropical Agriculturist, October, 1906.

† Tropical Agriculturist, Colombo, October, 1906.

liquid condition is intended to do away with this process at a later stage in the manufacture of the rubber goods, and to thereby effect a saving in time and power.

It should, however, be pointed out that the processes through which raw rubber has to pass in the manufactories are not designed solely for the perfect mixing of sulphur with rubber, but for the removal of various impurities—economically impossible once the latex has been sulphurised—and the admixture of various compounding ingredients, known only to the trade.

If the direct treatment of the latex is to be of avail to the European producers in the tropics it appears to be necessary to first remove undesirable impurities and subsequently add not only the required sulphur but the balance of compounding ingredients commonly used. It is difficult to see how the admixture of sulphur alone to ordinary latex, can, at present, be a very great saving of labour to manufacturers who deal with wild and plantation rubber; it still leaves the raw rubber of the wild forests to be dealt with on old lines, and prevents the removal of undesirable original components from the latex so sulphurised.

The treatment of the latex while in a liquid condition necessitates the introduction of various arrangements not at present in common practice. It is necessary in the first case to keep the latex in a liquid condition from the moment it leaves the tree to its arrival at some central factory and to so treat the latex that it will not deteriorate during transit. Experience has taught most people that the whole of the latex cannot be collected as such, a large proportion invariably drying up as scrap; especially with latex other than that from *Hevea brasiliensis*. It is also maintained that the addition of ammonia and formalin—especially the former—is not always accompanied with constant results, and the latex, owing to its very varied composition, is difficult to standardize. These difficulties, though somewhat serious, can be overcome once the process of treating the latex with sulphur and other ingredients is pronounced a commercial success.

The idea was criticised in the "India Rubber World" and the "India-Rubber Journal"; the editors stating that the process, though of interest, was not one which could be regarded as being of much commercial value to manufacturers.

SULPHURISING FRESHLY-COAGULATED RUBBER.

When the coagulation of the latex is complete the rubber is in a very soft, spongy state and can be easily torn into very small pieces, kneaded, rolled or pressed into any desired shape. On some estates experiments have been made with the freshly-coagulated rubber

while in this condition, mixtures of sulphur with other ingredients being added and after thorough mixing pressed into blocks or sheets and dried. It is obvious that rubber so treated possesses the maximum amount of resinous, protein and other impurities and if washed after the additional compounding ingredients have been mixed with it, a loss of the latter may be occasioned.

The mixing of foreign ingredients with rubber, if ever considered desirable, can, as far as ordinary estates are concerned be best carried out when the rubber is in the freshly-coagulated spongy state; to adopt such a treatment, on the plantation, with the rubber after it has passed through the washing machine would not be attended with satisfactory results.

It has been claimed that the addition of these ingredients prevents the rubber from becoming soft or tacky, and that there is an improvement in the physical properties of the rubber: the tackiness or softening may, however, be obviated by careful work during drying and washing or the addition of suitable antiseptics to the latex. Except it is desired to conduct the manufacturing operations in the tropics there appears to be very little in favour of adding a small percentage of certain vulcanizing and compounding ingredients to the freshly-coagulated rubber: the writer certainly does not know of any manufacturers who have called for rubber in that condition.

QUANTITY OF INDIA-RUBBER IN COMMON ARTICLES.

The important part which india-rubber and sulphur, together with other substances, play in the manufacture of articles in common use, is little less than remarkable.

The following analyses are given by Weber:—

	1	2	3	4	5
	Roller Covering.	Steam Packing.	Outer Cover of a Tyre.	Tobacco Pouch.	Garden Hose.
	per cent.	per cent.	per cent.	per cent.	per cent.
Indiarubber ..	24.49	12.73	54.70	50.22	31.29
Free sulphur ..	1.23	2.10	0.88	0.27	1.83
Sulphur of vulcani- zation ..	0.84	—	1.99	2.72	2.15
Mineral matter ..	72.33	62.81	41.08	2.19	26.28
Organic extract ..	1.10	2.82	1.34	4.88	7.34
Carbonaceous matter	—	19.53	—	—	—
Fatty substitute ..	—	—	—	37.21	28.90
Chlorine in rubber ..	—	—	—	2.50	2.20

The presence of as much as 50 to 54 per cent. of india-rubber in an ordinary tyre and tobacco pouch, the use of nearly 30 per

cent. of fatty substitutes in garden hoses, and over 70 per cent. of mineral matter in roller covering made from fine Para, should be noted.

RUBBER IN TYRES.

A considerable amount of analytical work has been done in Europe with the object of determining the composition of rubber tyres. Schidrowitz and Kaye* conducted an examination of tyres of representative makes and the following are analyses of several brands which they investigated:—

TABLE I.—*Covers.*

Mark.	B.	D.	D.	E.	F.
Part of tyre	Tread.	Tread.	Body.	Tread.	Tread.
Condition, &c. ...	Good.	Very badly flaked and "sun-cracked."	Good.	Badly cut, but not "sun-cracked."	Good; little used.
Specific gravity: apparent ...	1.135	1.2901	0.9567	1.272	1.3000
India-rubber ..	per cent. 69.10	per cent. 53.07	per cent. 83.76	per cent. 65.00	per cent. 30.82
Organic extract.. ..	5.80	3.13	4.54	7.90	9.50
Sulphur: Total	5.80	4.00	4.90	9.80	2.78
Sulphur of Vulcanisation...	3.14	2.12	2.94	3.97	0.97
Sulphur: Free	2.30	1.27	1.96	4.22	1.32
Sulphur in mineral matter	0.36	0.61	—	1.61	0.49
Mineral matter	19.30	39.80	6.80	17.30	56.80
Fatty substitutes ...	Nil.	Nil.	Nil.	Nil.	Nil.
Organic extract: rubber ...	7.70	5.50	5.10	10.80	23.50
Co-efficient of vulcanisation	4.50	3.90	3.50	6.10	3.14
Sulphur (excl. mineral sulphur): rubber... ..	7.80	6.4	5.80	12.6	7.4
Oxidation ("sun-cracking" test)— mgrms. of oxygen absorbed per sq. cm. ...	(a) 4.8 (b) 4.1	1.8	—	(a) 6.6 (b) 5.9	—

Schidrowitz and Kaye, concluded that manufacturers are by no means agreed as to the quality of rubber and mineral matter to be used; certainly the analyses published show that the proportion of rubber is very variable in the covers examined.

* Journal of the Society of Chemical Industry, February 28th, 1907.

Clayton Beadle and Stevens* subsequently gave an account of their investigations into the composition and value of tyre rubbers; the following are results obtained with solid tyres :—

Sample.	1.	2.	3.	4.
Resins, &c., (acetone extract), per cent. ...	9.0	8.6	7.2	7.4
India-rubber substitutes (alcoholic potash extract), per cent. ...	10.2	8.9	9.1	11.7
Mineral matter (ash), per cent. ...	38.5	39.2	40.7	33.2
India-rubber (caoutchouc) by difference, per cent. ...	42.3	43.3	43.0	47.7
Total sulphur (calculated on caoutchouc), per cent. ...	7.8	9.0	10.0	11.3
Free sulphur (calculated on caoutchouc), per cent. ...	3.5	3.7	5.6	6.1
Combined sulphur (calculated on caoutchouc), per cent. ...	4.3	5.3	4.4	5.2
Tensile strength, grms. ...	3718	2509	3403	3217
Elongation at rupture, per cent. ...	55	38.5	52	45.5
Elongation under a strain of 1500 grms, per cent. ...	23.5	24	24.5	26.5

USES OF RUBBER.

The uses of Para rubber have been greatly augmented in recent years by the increased production of automobiles and accessories, and it is difficult to accurately forecast what the demand for rubber will be when it is more generally adopted for wheeled traffic and public passenger vehicles in many parts of the world. It has also been largely used in the making of tiling, balls, boots, articles of clothing, instruments, belting, &c., and "solution." Plantation rubber is said to be preferred by many manufacturers for "solutions," on account of their being able to use it direct with the solvents without purification.

Exactly how much plantation rubber is used for certain purposes is not known, but in view of the fact that somebody must buy and use plantation Para, even though it is described as, and known to be, inferior to fine hard cure, the India-Rubber Journal† circularised manufacturers and asked them if they would state for what purposes they found plantation rubber (a) useful and (b) useless. One firm replied that they found plantation rubber useless in the manufacture of elastic thread, and that they had no special purpose for which plantation rubber could be used; whilst another firm, which frankly pointed out that competition in business did not permit their informing the

* Chemical News, August 2nd, 1907.

† India-Rubber Journal, September 23rd 1907.

public for what special purposes they found plantation rubber useful, hastened to state that for several purposes they found this class of rubber useless! Other firms replied that they found plantation rubber useful in the making of buffers, soles and heels for boots and shoes, motor tyres, etc.

Plantation rubber will, undoubtedly, be more largely used when it can be procured at cheaper rates and from older trees.

DIRECT USE OF PLANTATION RUBBER.

Stevens * discussing the question of the direct treatment of plantation rubber for mastication and mixing, says it is one of considerable importance. If the latex was properly coagulated and the resultant mass thoroughly washed and dried on the plantations before exporting, it would appear superfluous for the manufacturers in this country to go through the whole process a second time, especially when the rubber arrived in the excellent condition in which it is now being received from well equipped estates. This would save the manufacturer the softening in warm water, followed by the washing and drying operations, the latter being a particularly slow process, especially if the rubber is stored for the purpose of allowing it to regain the peculiar physical condition in which it yields the best results on vulcanization.

It is, of course, open to question how far it is permissible to draw general conclusions as to the behaviour of caoutchouc under manufacturing conditions from experiments with small quantities carried out on a laboratory scale, but if the latter may be taken as a guide it should be possible to masticate and mix washed and dried plantation rubber without any preliminary treatment, save perhaps a very short sojourn in the drying rooms to remove superficial moisture, and provided also the rubber is put up in a convenient form for treatment between the mixing rolls.

TESTS WITH VULCANIZED PLANTATION RUBBER.

Messrs Clayton Beadle and Stevens have published, in a recent issue of the Chemical News, an account of their experiments with plantation rubber. They vulcanized samples of plantation and fine hard Para rubber; the products from the former were clear, transparent, yellow to brown shade when viewed through sheets 1 mm. thick; the latter were much darker and less transparent. The average tensile strength and elongation of vulcanized plantation rubber samples was 3203, and that of the

* Rubber Cultivation in the British Empire, (page 94), MacLaren and Sons, Shoe Lane, London, 1907.

vulcanized fine, hard Para 3013; the average elongation at the moment of rupture for the plantation lots was 13.1 and for the fine hard Para 12.7. They therefore concluded that the plantation product would prove equal to Amazonian Para; they also subsequently proved in their tests on vulcanized plantation rubbers prepared from "Block" rubber containing mineral matter, that the addition of mineral matter had the effect of increasing the tensile strength while reducing the elongation.

These results are very interesting but at the outset it should be pointed out that Beadle and Sievels dealt probably with the best block plantation rubber on the market. A perusal of their work gives one the impression that plantation rubber is quite equal to, if not better than, hard fine Para. Practical manufacturers, whose experience in this regard is surely unique, are, we believe, of a decidedly different opinion. It is believed that the latex obtained from mature plantation *Hevea* trees and coagulated in the proper manner is not in the long run, likely to prove in any way inferior to the wild Para latex, and the reasons for the lack of "resiliency" or "nerve" of much of the plantation product must be looked for in other directions, particularly in the tapping of immature trees, etc., and of the employment of methods of coagulation which are not quite suitable.

The same chemists * have since published the results of their tests with hard-cure which had been washed and dried by a manufacturer and was therefore in the exact condition in which it would be used by the manufacturer himself. The hard-cure Para supplied by the manufacturer yielded lower figures for tensile strength than the plantation rubber. They finally point out that different forms of plantation rubber differ materially from one another and suggest that planters will require to consider carefully whether the form in which they are shipping their rubber is that which yields the best results to the manufacturer.

SYNTHETIC AND ARTIFICIAL RUBBERS, AND SUBSTITUTES.

During the latter part of 1907 the writer was frequently consulted regarding various artificial rubbers then on the market and the current rumours respecting synthetic rubber. Confused criticisms and comments have recently appeared in some sections of the Press, and as the subject does not appear to be yet clearly or fully understood, a simple explanation of the position can, advantageously, be given here

Vulcanization Tests with Plantation Rubber, *Chemical News*, Oct. 18th, 1907.

DEFINITION OF SYNTHETIC RUBBER.

As pointed out elsewhere * synthetic rubber may be defined as one built up by chemical means from various substances, and possessing all the chemical and physical properties of natural rubber. As a standard for natural rubber one may take that obtainable from *Hevea brasiliensis*.

Now, natural rubber consists, chemically, of very complicated compounds, the most important of which are distinguished by the terms caoutchouc, resins and proteins; water and various mineral substances also generally occur in raw rubbers, but need not be specially considered here. These have been dealt with in the chapter on this part of the subject. It may not be well known to many, but it should, nevertheless, be borne in mind, that some of the foremost rubber chemists of the day frankly acknowledge their ignorance regarding the exact chemical constitution of some of the substances which normally occur in almost every sample of natural rubber.

The substances referred to in such empirical terms as "resins" and "proteins" are in themselves highly complex bodies, the components of which, though recognised, and conveniently grouped together, are but little understood. Caoutchouc, the essential and therefore the most important constituent of natural rubber, has received more attention from chemists than the average person ever dreams of, and yet it has never been made successfully on a commercial scale. A small quantity was once obtained by an eminent chemist, but concerning it there has been very little progress, of commercial importance, to record up to the present time.

How can it then be possible, since we do not fully understand the chemical composition of the various components of natural rubber, to have synthetic rubber already on the market?

One of the greatest chemists of the day recently declared, that he was incredulous of the production of synthetic rubber, commercially, at any price. The writer can confidently state that we have never seen a sample of synthetic rubber (the term is here used in the strict, scientific sense), though time after time he has received samples of artificial rubbers, and so-called rubber substitutes. Furthermore, he can emphatically declare that he does not know of the production, on either a laboratory or commercial scale, of synthetic rubber.

It is obvious that no one can, for a moment, say that it is impossible to ever discover substitutes or substances having some of the characteristics of natural rubber; that would, to say the least, be under-estimating the possible achievements of chemical

* India-Rubber Journal, October, 1907.

science, if not idly attempting to negative what has been achieved long ago. Every one must know that natural rubber alone, though it is very tough, would be of little use if not compounded with various substances; mixing is one of the most important branches of the rubber industry, and many developments may be expected in that direction.

MISUSE OF TERMS.

At the same time one strongly objects to the gross misuse of the term "synthetic rubber"; its application to any substance which is remarkable for its lightness in weight or elasticity is not justifiable, and in my opinion should never be allowed. Boiled sea weeds or bones give light, elastic, gummy substances but it would obviously be unfair to refer to these, even in the most popular sense, as synthetic rubbers. High-grade and low-grade natural rubbers, when mixed with balata or gummy extracts, may show considerable improvement in physical properties, and this may be especially true of resinous, low-grade, rubbers; but no competent chemist would allow the improved product, so derived, to pass under the name "synthetic rubber." Nevertheless, the term is being very loosely used in reference to substances which are merely vulcanized or oxidized oils, or to materials which have as their basis a varying proportion of natural rubber.

ARTIFICIAL RUBBERS.

Artificial rubbers and rubber substitutes are known by the score. They are substances usually derived from some organic source, and generally possess one or more of the physical characteristics of natural rubber. The chemical constituents in artificial rubbers or rubber substitutes need not, however, be even remotely related, chemically, with those in the natural article; in this particular lies one of the great differences between them and real synthetic rubber.

One might with advantage distinguish between artificial rubbers and rubber substitutes; the former being roughly defined as substances containing, essentially, a quantity of natural rubber, together with other substances, and the latter as materials derived from sources other than crude rubbers.

COMPOSITION OF AN ARTIFICIAL RUBBER.

The desire to place on the market a comparatively cheap composite mixture having physical properties similar to raw rubber is strongly marked. From time to time samples for report and analysis are received; when they possess characters of value to rubber manufacturers they usually contain, as an essential component, a proportion of rubber, reclaimed or otherwise. In the "Gummi-Zeitung" an analytical account is given of material

submitted as "an artificial rubber prepared from vegetable fibres" to Drs. Marckwald and Frank. The following details are given regarding the composition of this substance:—

	Per Cent.	Per Cent.
Moisture, volatile at 100 deg. C.	...	12.86
Acetone extract	...	61.50
Which consisted of—		"
Saponifiable constituents	... 9.44	
Unsaponifiable constituents	... 49.88	
Sulphur	... 2.18	
Mineral constituents	...	7.16
Sulphur combined with rubber	...	3.00
Rubber substance	...	15.48
		<hr/> 100.00 <hr/>

In such a sample it is obvious that 100 parts of rubber are combined with about 19 parts of sulphur. The mineral constituents are said to have consisted largely of alumina, containing quantities of iron oxide, small quantities of chalk; magnesium carbonate was also present. Chemical tests further revealed the presence of starchy and resinous compounds. In conclusion, it is stated that the "artificial rubber" under investigation may be regarded as having been derived from an inferior reclaimed rubber containing sulphur and mineral substances, and cannot lay claim to being an artificial rubber in the true sense of the term.

IMPROVED LOW-GRADE RUBBERS

There has been recently placed on the market a preparation, made by a secret process, which is said to possess excellent qualities. It is made essentially from guayule rubber and certain gummy substances, and a large factory has been established for its manufacture. The manufacture of this substance—which may be described as an artificial or modified rubber—has been going on for some time, and already large quantities of the improved product are being turned out from the factories. It is obvious, however, that in the preparation of this class of rubber, materials, very expensive in themselves, have to be used, guayule rubber alone standing at one to two shillings per lb. Furthermore, the necessary ingredients are obtained from plants which grow very slowly, and the method of extraction is often such as to involve the destruction of the plants whence they are derived: it is therefore obvious that the natural sources of supply may be partially exhausted before many years are over. But what puzzles the writer is that this new substance, which from all accounts appears to be nothing more than an improved low-grade rubber, should have been referred to as "synthetic rubber."

SUBSTITUTES FOR RUBBER.

Rubber substitutes are already largely employed in the manufacture of certain india-rubber articles and large factories have long been established for their preparation. Vulcanized oils, the preparation of which is rendered possible on account of the action of sulphur and sulphur chloride on various oils and fats, are largely used as rubber substitutes. In the manufacture of these substitutes processes somewhat similar to those used in the vulcanization of india-rubber are carried out, hence the reason why they are described as vulcanized oils. Linseed, rape, poppy seed, cotton seed, castor, and numerous other oils are used in this way, as well as substances having a gummy and resinous texture. There has never been any attempt at secrecy in connection with the use of these substitutes as most people know that rubber would be of very little use if it were not mixed and compounded with various substances.

TERRY'S OPINIONS OF SUBSTITUTES.

Terry* in dealing with india-rubber substitutes states that the efforts inventors have made to discover or prepare a substitute for rubber have been very noticeable, but up to the present time no real substitute has been discovered. In his opinion the substitutes which have so far been used have no status beyond that of cheapening ingredients and not until some substance, which on admixture with rubber cheapens it without at the same time reducing its quality, can be claimed as a desirable substitute. He makes a pertinent remark to the effect that the great bulk of the rubber substitute inventions have benefitted no one except those who are professionally concerned with patents and that the present prospects of wealth for the discoverer of a rubber substitute are largely illusionary. It is, however, pointed out that in the manufacture of rubber articles where elasticity is not really required, *e.g.* waterproof goods, door mats, etc., certain substances may be legitimately used which will not impair the efficiency of the manufactured article.

In Ceylon the Telephone and Telegraph sections of the Post Office Department have, according to Mr. Cook, been contemplating the use of the paper and dry air insulation afforded by the so-called Dry Core cables for underground and sub-aqueous extensions, but the local conditions are so peculiar in regard to the soil and the atmosphere, that the engineers have not made up their minds as to the desirability of the change from vulcanized rubber insulation. Nevertheless, cheap substitutes are being used in cable work in many parts of the world.

* India-Rubber and its Manufacture ; by Hubert L. Terry, 1907.

Burgess, as a result of inquiries made during 1905 in Europe, was able to state that land cable carrying telephone wires, which at one time were insulated with rubber, are now largely insulated with dry paper, and that heavy cables for electric light supply are demanding for use in their manufacture less and less rubber every year, its place being taken by papier-maché and cellulose pulp. He attributes this to the high price of raw rubber, and is of the opinion that there will be a great extension of the electrical application of rubber when the price of raw rubber is reduced.

Guttapercha has been tried both in Ceylon and India, but the consensus of opinion is that for tropical installations it is far inferior to indiarubber.



CHAPTER XVIII.

KINDS OF PARA RUBBER.

Plantation and fine hard Para—Differences between Plantation and Wild rubber—Inferiority of plantation Para rubber—Opinions of india-rubber manufacturers on plantation rubber—Observations by Burgess—The smoking method of plantation rubber—Prevention of putrefaction—Chemical and physical tests—Similarity in chemical composition and differences in physical properties—Physical properties of rubber from Ceylon and Malayan estates—Forms of plantation rubber—Packing rubber—Ventilation of packing cases—Biscuit and sheet—Size and shapes—Crêpe—Worm—Conversion of worms into crêpe—Lace—Flake—Scrap—Purification of scrap rubber—Colour of plantation rubber—Block rubber—Method of preparation—A communication from Lanadron estate—Size of blocks—Blocking dry rubber—Presses for blocking rubber—Brown and Davidson's press—Shaw's block press—Bridge's presses—Kinds of plantation rubber: manufacturers' advice to planters—Small lots of rubber: brokers' advice to planters—Analyses of plantation rubber.

DIFFERENCES BETWEEN PLANTATION AND WILD RUBBER.

THE comparison of the kinds of Para rubber may appropriately be prefaced by a few remarks regarding the differences between Plantation and Wild or fine hard Para rubber, the former being obtained from the newly-planted trees in the Tropics and the latter from the wild trees in the Amazon District.

The methods of preparation in the East are such that Plantation rubber is made much purer than fine hard Para; it contains very little, if any, moisture, and is obtained with or without the use of chemical reagents. It is, of course, usually obtained from younger trees than fine hard Para. Plantation rubber, when placed on the same market as "wild," obtains a higher price, weight for weight, because of the small quantity of water and other impurities present, the loss on washing being only about 1 per cent. as against 10 to 20 per cent. for some grades of fine hard Para rubber. The extraction of the impurities from the latter rubber is not always very troublesome, and if allowance is made for the large quantity of water it contains the price realised is really much better than that for Plantation rubber free from moisture.

The preference of manufacturers for purified fine hard Para rubber is said to be due not so much to its being obtainable in large quantities, as to the fact that its properties are much more superior and constant.

The "India-Rubber World" recently stated that several manufacturers in Great Britain were unable to give their opinion as to the value of Plantation Para rubber, but they all seem agreed that there was a wide variation in its quality as received in England.

Examples are known of specimens of pure Para Plantation rubber which in two years have resolved themselves into a gummy substance void of all the desirable properties of india-rubber, whereas samples of purified fine hard Para rubber have been perfectly sound after seventy years. Plantation rubber is usually regarded as wanting in resiliency and recuperative power, but when put on the market as clean biscuit, crêpe, or worm rubber, is eagerly bought on account of its purity and, therefore, adaptability for "solution" purposes.

The "India-Rubber Journal" (Sept. 23rd, 1907) when discussing the inferiority or otherwise of Plantation rubber stated that they had long held the opinion that the age of the trees, the frequency of tapping, the method of coagulation, and the use of antiseptics were factors which influenced the quality of crude rubber. The trees on most of the eastern plantations are quite young, they are often tapped in a manner which does not allow the constituents of the latex to mature, the coagulation is effected by using reagents which do not give the best results, and the use of antiseptics in the latex and rubber has only been recently prominently brought forward; under such conditions, one may expect that the quality of plantation rubber cannot be equal to that of hard fine Para, but must continue to improve year by year as the trees get older and the systems of rubber production are improved.

Some prominent firms place Plantation rubber in a superior position; in order to ascertain the views of European india-rubber manufacturers on the value of plantation rubber the same Journal made a direct appeal to them, and requested them to state whether they considered plantation rubber inferior, or otherwise, to wild rubber, for general manufacturing purposes. The results of that enquiry were that 30 per cent. of the manufacturers declared in favour of plantation rubber and 70 per cent. pronounced it inferior to average wild rubber.

The "India-Rubber World" (March 1st., 1907) in discussing this question pointed out that though a wise manufacturer would not dare, leaving out of the question the interest on investment, to

buy 50 tons of cultivated Hevea rubber and store it for six months, because he would be afraid of the very appreciable deterioration in quality, yet he would buy thousands of tons of upriver fine Para and store it with a full knowledge that it would not grow worse in storage, but would grow better. This is surely one of the most vital considerations and one to be commended to the planting community as deserving of their first and best attention.

The opinion in many quarters is that the use of chemicals such as acetic acid, formalin, &c., should not be continued if the Plantation rubber can be effectively prepared and purified by mechanical means.

Burgess, in his report upon a visit to Great Britain to investigate the india-rubber industry and its relation to the growth and preparation of raw rubber in the Malay Peninsula, states that the manufacturers who had tried Plantation rubber from Ceylon and the Straits were agreed that the "rubber was good and very serviceable, but that it was by no means as good as South American fine Para, either hard or soft cure. The Plantation rubber is lacking in "nerve," it works soft between the masticating rollers, and its keeping qualities are inferior to South American Para. After vulcanization the tensile strength is less, and the elastic recovery of shape after deformation by stretching or compression is less perfect than South American Para under precisely similar conditions. He further points out that the Plantation rubber shows an inferiority from 8 to 15 per cent. compared with wild Para, and that this inferiority is not only in the physical properties which are capable of immediate measurement, but also in the keeping qualities of the rubber, the plantation samples often tending to become soft and gummy whilst wild Para remains tough and elastic after many years' keeping. Burgess suggests that the superiority of the wild Para may be due to the fact that the rubber trees of South America which are tapped, are selected both by natural and artificial selection, and therefore only the best and oldest trees are used as sources of rubber. This idea is original, but does not appear to be supported by results obtained from the old trees at Henaratgoda and Peradeniya, where only the first tappings gave tacky or soft rubber; or by the observations quoted by Jumelle.

THE SMOKING METHOD AND PLANTATION RUBBER.

In a communication to the Press dated March 22, 1906, Messrs. Lewis & Peat point out that consignments of biscuits have arrived in London in a heated and sticky condition, and raise the query as to whether the present mode of preparing biscuits is the best. It is pointed out that Amazon-grown smoke-cured rubber is still the standard, and has for a record of 50 years maintained its reputation for elasticity, strength, and durability.

It has been pointed out, elsewhere, how Para rubber is smoked in Brazil, and in addition to the nuts of specified palms certain antiseptic reagents such as creosote, dilute hydrofluoric acid, and corrosive sublimate have been mentioned as being of use in the preparation of rubber. It has also been shown that rubber prepared from trees 30 years old may, if not properly dried, become quite as heated or tacky as that from young trees. If a larger proportion of moisture is left in Plantation rubber, putrefactive changes will be more apt to occur, and the use of antiseptics either by direct application to the latex or by smoking or coating the rubber will be imperative. In any case, the coating of the rubber particles or smoking the freshly-prepared rubber crêpe or sheets with any antiseptic is always an advantage as far as the keeping properties of the rubber are concerned; most of the heating or tackiness in Plantation rubber is due to bacteria which can be prevented from spreading by the use of antiseptics; if not destroyed they will lead to putrefactive changes in rubber with which they are brought into contact. It is really a disease which in unsmoked rubber can certainly be spread by contact; but whether it is more likely to develop on rubber from young or old trees, is still a point to be determined. If the consumers will accept the Plantation rubber, prepared by the use of antiseptics as described, the producers will find no difficulty in meeting their requirements; in fact, several Ceylon estates have, for some time past, sent their rubber to Europe in the smoked condition, but whether better average prices for large quantities have been obtained is not known to the public.

The subject of Plantation versus wild fine Para has been discussed in a recent issue of the "German Rubber Trade Journal," by Gustave van den Kerckhove, and, as in other communications, the writer points out that fine Para has not been deposed by the plantation product, and that the former probably owes its better physical properties of elasticity, durability, &c., to the creosote emitted during the smoking process.

CHEMICAL AND PHYSICAL TESTS.

The inferiority of Plantation rubber is commonly attributed to the trees being immature as compared with those in the Amazon District. But it has been previously shown that in the Amazon District trees are tapped when they are 15 years old; when forest Para rubber trees are 25 years old they are described as having reached maturity. In view of these facts it is interesting to reflect on the chemical analyses of rubber from trees 4, 6, 8, 10-12, and 30 years old, given elsewhere. These analyses have been made from rubber obtained from Ceylon-grown trees, and it is fortunate that the age can be guaranteed. They show very clearly that the variation in chemical composition between the rubber from young and 30-year-old

trees is insignificant, and that the reputed defects of rubber from young trees cannot be explained from the differences in the chemical analyses given. There is as much variation between the chemical composition of samples of rubber from trees of the same age as between those given for the material obtained from trees 4 to 30 years old; ordinary analytical methods do not appear to give many indications of the great differences in physical properties. From these and other considerations one feels compelled to seek for some other tests, of a physical nature, whereby the rubber may be scientifically classified, and which will allow of the value being calculated on a sound basis. Colour cannot be accepted as a guide, though preference seems to be given to the pale amber colour by many manufacturers; only in the case of really bad samples can odour be taken as indicating quality, as the best biscuits have often a cheesy putrescid smell which is more or less transient. In this chapter it will be seen that certain physical tests have been devised, and the results obtained with samples of Plantation rubber from the East are given. It is not impossible that the physical properties of rubber will ultimately be associated with the quantity and nature of the ingredients indicated in the numerous chemical analyses which have been quoted. At the present time the valuation of different kinds of Plantation rubber is not usually based on chemical analysis, except by a few firms on the continent of Europe, but mainly on appearance and physical characters

The "India-Rubber Journal" recently published a series of reports regarding various samples of Plantation rubber from the East. Opinions as to the strength and general value of cultivated rubber have shown considerable variation. Though the conclusions embodied in the previous paragraph may be taken as representing the opinions of a large number of manufacturers, yet it has frequently been stated on good authority that cultivated Para rubber was equal in tensile strength to native-cured Para, and after vulcanization gave very good results. The differences in strength noticeable in Plantation rubber are usually ascribed to the tapping of young trees and irregularity in mixing the latex from trees of different ages; the latter cannot help but occur on small estates, where only a small proportion of the trees are even ten years old.

Regarding certain samples of Plantation rubber it has been stated that when worked on the mill the light coloured samples gave the odour peculiar to fine Para when prepared without the use of smoke.

On the mill they prove to be much softer than dry sheet Brazilian Para. They also take the "compound" much more rapidly than the Amazonian variety. To assist in comparing the tensiles obtained from the several brands of Plantation rubber the data are presented in tabular form. The term

"Tensile" means the pounds required to break $\frac{1}{4}$ in. by $\frac{1}{4}$ in. in section of the compounded rubber.

Conditions. Steam Pressure.	Time. Min.	CEYLON SAMPLES.			OTHER SAMPLES.	
		Dorana- kande.	Sudu- ganga.	Kalu- tara.	Bukit Rajah.	Pata- ling.
lb.						
5	.. 10	50	121	99	83	97
5	.. 15	77	113	138	115	136
45	.. 20	88	143	133	104	140
45	.. 25	78	127	121	107	125

From the above analyses the same Journal proceeds to state : (1) "That Ceylon Para when used to denote the Oriental source of fine Para means a grade *lacking in uniformity*, when the tensile strength is considered ; (2) the curing qualities of Ceylon fine indicate that it has a decidedly slower action than the South American product ; (3) all the Oriental samples are much softer and less nervous than the Occidental types."

FORMS OF PLANTATION RUBBER.

Having compared the differences of Plantation and Brazilian rubber, it now remains to deal with the various forms of the cultivated rubber ; they are briefly (1) sheet, (2) biscuit, (3) crêpe, (4) worm, (5) lace, (6) flake, (7) scrap and (8) block rubber.

PACKING RUBBER.

In packing Plantation rubber the packages, which should be strong and well hooped, should not exceed one to two cwt. in weight ; a little Fuller's earth can, according to some authorities, be used. It is not advisable to pack the rubber between paper. The rubbers should be graded and all "heated" material kept separately.

The desirability of ventilating cases in which plantation rubber is shipped appears to be very questionable. Some manufacturers have suggested that planters should ship their rubber in air-tight cases, but on the other hand a few planters have had cause to regret having adopted that system, owing to the arrival of their rubber in Europe in a heated condition. It is obvious that block rubber has an advantage over sheet and crêpe in so far that proportionately less surface is exposed to the air ; one might, therefore, feel inclined to argue that packing in air-tight cases, to minimise oxidation, would be advantageous. But one must realise that it is impossible to ship rubber in vacuum cases ; air must always be present. To lock up rubber in an air-tight case may simply result in imprisoning foul gases during transit, and if there is any tendency towards tackiness at the time of packing the whole consignment may arrive as a treacly mass.

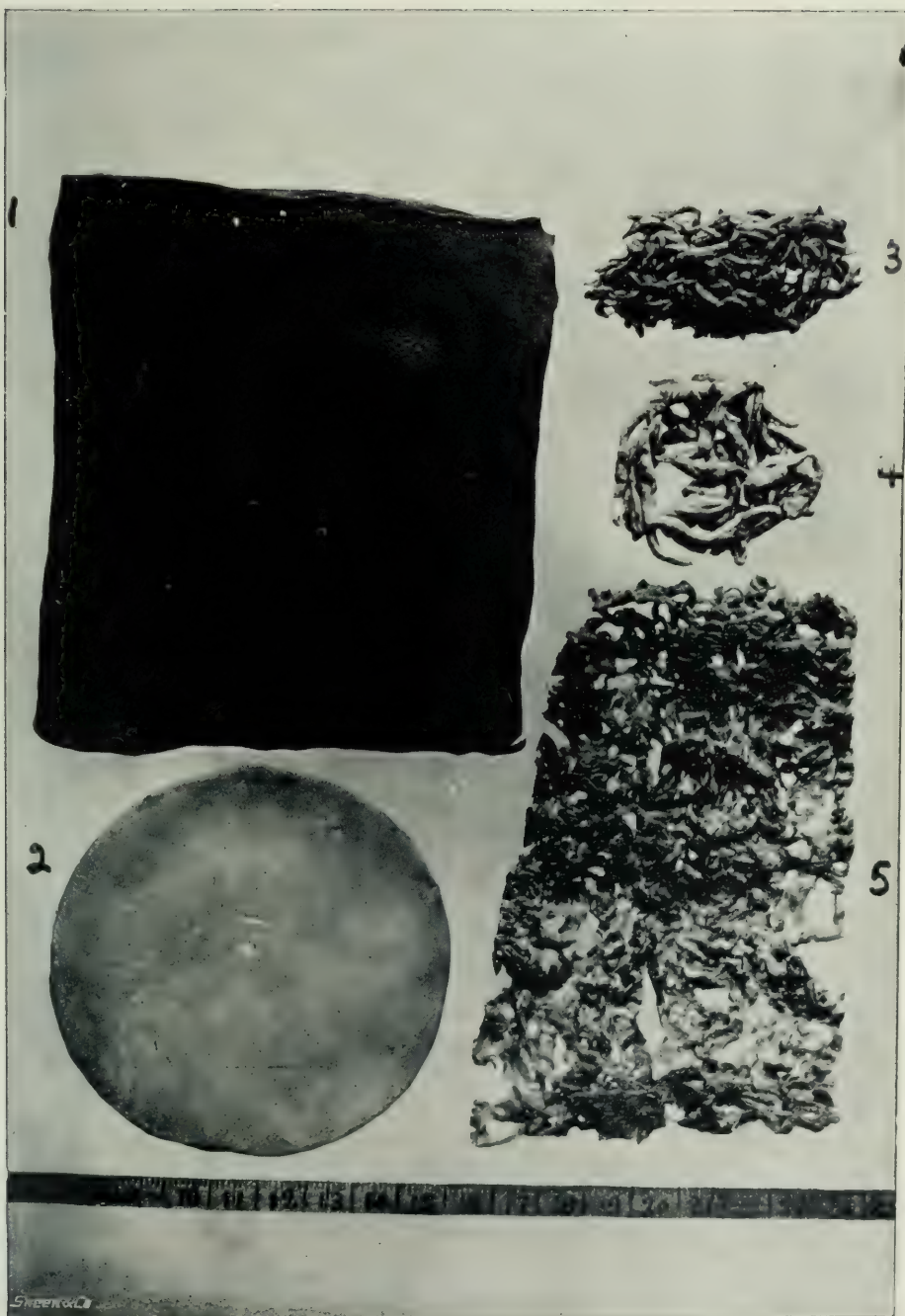


Photo by H. F. Macmillan.

KINDS OF PLANTATION PARA RUBBER.

(1) SHEET: (2) BISCUIT: (3) & (4) WORMS: (5) LACE.

BISCUIT AND SHEET RUBBER.

Biscuit and *sheet* rubber are commonly met with, and are prepared by allowing the latex to set in shallow receptacles, with or without acetic acid, and washing and rolling the cake of rubber which appears at the top. The biscuits are more or less circular and the sheets rectangular in outline. They are sometimes pressed together to form blocks; the sheets, on account of their shape, lend themselves to more economic packing than many other forms.

According to many London brokers there is a tendency for shipments of sheets of rubber to be taken in preference to biscuits, those having a clear amber colour and measuring about 2 feet by 1 foot having obtained high prices. Biscuits which were clear and pale amber-coloured have obtained high prices.

An adviser to Messrs. Lewis & Peat is of the opinion that biscuits and sheets will have to be abandoned in favour of balls or other forms like those in which fine Para arrives in Europe, as the former are very liable to become heated or tacky. He argues that "the very form of thin biscuits lends itself to heating when under pressure, whereas the ball shape and thick biscuits are far less liable to this change;" he prophesies that when the rubber is arriving in tons the defects will be very evident by the state the material arrives in and that even if the rubber does not get heated on the voyage it will inevitably do so if stored for any length of time in the warehouse. He gives as proof of his theory that the same thing occurred to certain other rubber, and the remedy in that case was making it into large balls.

Sheets measuring 24×12 inches or more and $\frac{1}{16}$ to $\frac{1}{8}$ inch in thickness are received with favour in Europe.

SIZE AND SHAPE, &c., OF BISCUITS.

In many instances the biscuits, on drying, curl up at the edges and present an objectionable appearance. This can to some extent be overcome by pressing them in a vessel of definite outline before subjecting them to the rolling process; after rolling, the cakes partake of the shape of the vessel in which they were pressed; if the margins of the latter are correctly made the tendency to curl and become wavy in outline is not as noticeable.

Biscuits and sheets are usually very pure, and can, without washing, be used for "solution" work by the manufacturers; the material is practically ready for the naphtha bath on its arrival in Europe. It has been stated that the material from Ceylon shrinks about 1.4 per cent., and that it is not liked for cements. In past times it has been very irregular in quality, sometimes being little better than elastic gum, sometimes sticky and only equal to recovered rubber in elasticity. The rubber biscuits from old Para trees are tough and

elastic, and much of the irregularity referred to might to some extent be obviated by not mixing the tappings from trees of different ages. If the irregularity in quality is allowed to continue, it may spoil all prospects for use of our rubber in fine work, such as thread, bladders, &c., and if the "solution" market should, at the same time, become overstocked the position might under such circumstances be embarrassing to rubber planters.

Biscuits should be made from $\frac{1}{16}$ to $\frac{1}{8}$ inch in thickness and 10 to 14 inches in diameter.

CRÊPE RUBBER.

Crêpe rubber differs from the foregoing on account of the stretching and tearing it has undergone between the rollers of the washing machine and the low quantity of soluble and mechanical impurities it contains. It is, of course, only washed rubber, but it may have been obtained from purified scrap as well as the other class. It has an irregular surface, is very uneven in thickness, and like lace and flake rubber dries very rapidly. On account of its purity it has been well reported upon in Europe, and owing to the efforts of Burgess is likely to come to the front in Malaya. *Crêpe* rubber has been described in Europe as "fine pale, strong, quite clean, and in good condition." The material has been sold at a good price, but on account of the washing and re-washing which certain manufacturers subject *all* rubber to, it has been questioned as to whether the extra labour involved in its preparation will be paid for by the higher price. According to the "India-Rubber World" of December 1, 1905, very few consumers then looked upon this form of rubber with favour, most of them preferring to do the washing themselves.

The *crêpe* may be prepared in lengths of 3 to 6 feet, width 5 to 12 inches, and be graded according to colour.

Lewis and Peat stated in 1905 that "manufacturers are still prejudiced against any rubber that has been washed or otherwise treated, as a certain amount of the natural fibre and elasticity is lost in the process, and the true quality of the rubber is much more difficult to tell in this form; but the prejudice seems to be wearing off." In any case it will always rank as a relatively pure rubber, and will allow of the conversion of scraps and other kinds to one class of uniform standard.

Messrs S. Figgis & Co., in a letter dated October, 1907, state that they advise the preparation of all plantation rubber, whether first class or scrap, in the form of *crêpe* and are evidently more in favour of this form than even block rubber.

WORM RUBBER.

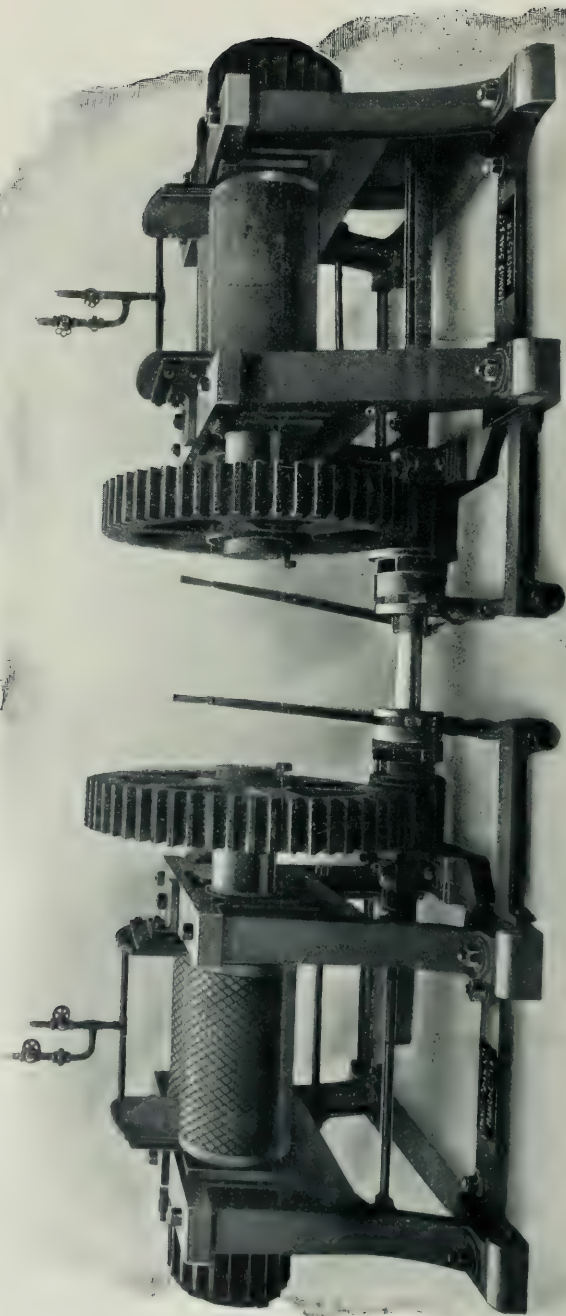
Worm rubber is essentially the product obtained by cutting irregular sheets of freshly-coagulated rubber into thin worm-like



Lent by Maclaren & Sons.

PLANTATION RUBBER IN LONDON.

^A
BLOCK, SHEET AND CREPE RUBBER IN THE SALE ROOM.



BREAKING UP AND CRÉPEING MACHINES.
Block lent by Brown & Davidson, Ltd., the Ceylon Agents.

rods of unequal length. The Michie-Golledge machine is used to coagulate the latex; the fresh rubber is rolled to express the water, and the irregular cakes are cut up by means of large shears, or machinery. The fresh rubber being cut into such fine parts dries quickly; the "worms" can be economically packed in ordinary tea boxes.

Lewis and Peat, in their report on Plantation Rubber for 1905, state that worm rubber is not so attractive as biscuits or sheets, and buyers are rather apt to treat it as a form of very fine scrap, although the quality is every bit as good as sheet or biscuits.

Samples of worm rubber have, up to the present, received good reports, the consensus of opinion being that the rubber so prepared was very clean and contained very little moisture: once it has established a name it might command a price equal to, or higher than, biscuits on account of its purity and dryness. An illustration elsewhere shows the freshly-coagulated spongy mass, which, after passing through the rolling machine also reproduced elsewhere, is ready for cutting into "worms."

By passing the dry worms through ordinary washing rollers they are bound together into an even strip of crêpe.

LACE RUBBER.

Lace rubber has been prepared by Mr. Francis Holloway, Matale. It consists of very thin perforated sheets of considerable length. In the preparation of lace rubber the latex is coagulated without the use of mineral acids or application of heat, and after being converted into "lace" is dried in air kept at about 95° F. The porous sheet is very thin, of a pale amber colour, and can be easily pressed into biscuits or sheets of any desired thickness. The "lace" comes out of the machine in a continuous strip; it is cut into pieces 6 feet long as it runs on to wire trays. The rubber is very thin and dries rapidly; it is maintained that it can be turned out ready for drying within seven minutes of the latex arriving at the factory. The time taken for coagulating the latex, conversion into lace rubber, and drying ready for despatch is 48 hours. Mr. Holloway assures me that only mechanical methods are adopted, a point of considerable importance. The illustration elsewhere shows the machinery used by Mr. Holloway.

FLAKE RUBBER.

Flake rubber is quite a recent introduction, and I have to thank Mr. C. O. Macadam, Culloden, Neboda, for the information on this form of rubber. Flake rubber was made by Mr. Macadam by placing small pieces of freshly-coagulated rubber in a small rolling machine or washer, the corrugations of which run horizontally; the rollers are close together and the cut rubber issues as thin strips. The

strips or flakes are very thin, and can be easily smoked and packed in any form. The sample I saw was pale amber in colour, free from mechanical impurities, and possessed good physical properties. It is apparent that the very thin flakes can be rapidly dried, and in this respect compares very favourably with crêpe or lace rubber. This form is seldom seen on the home market.

SCRAP RUBBER.

Scrap rubber is mainly the coagulated rubber obtained from the incised areas, rolled into balls or made up into cakes. It may be sent to Europe in the crude state, with all its mechanical impurities, or washed, purified, and converted into crêpe rubber before being despatched. Scrap rubber, if free from bark, dirt, and other impurities, obtains a high price.

PURIFICATION OF SCRAP RUBBER.

Having regard to the opinions of manufacturers as to the desirability of securing dry pure rubber, in preference to the wet creosoted form, and bearing in mind the objections which others raise against the use of rolling machinery in the preparation of crêpe, the "India-Rubber Journal" asked the manufacturers if they would state whether they preferred crêpe plantation rubber to be sent as purified scrap, crêpe or block, instead of in the usual impure form containing a large proportion of bark and other mechanical impurities. Only one firm suggested that the scrap should be sent in the condition in which it is when picked from the tapping lines. All the other firms agreed that the purification of scrap rubber was a thing to be desired, and are thus consistent in their demands for pure dry rubber of the first grade. Evidently there was a strong desire for purity of rubber among manufacturers, a demand which recently led the Governor of a native state of Brazil to give every encouragement to the purification of rubber before it left the Amazon Valley. As to the form in which the manufacturers desire to receive the purified scrap, the majority were in favour of small blocks, and a few in favour of crêpe. The purified scrap rubber, seeing that it has to be prepared by passing the scrap rubber together with pieces of bark, through the ordinary rolling machinery, cannot help becoming mixed with juices pressed from the dead and living bark cells. These are often such as to form a food supply for bacteria, which lead to the development of tackiness in rubber so prepared. If it is prepared in the block form this tendency is minimized.

COLOUR OF PLANTATION RUBBER.

The colour of unsmoked plantation rubber has evidently to be taken into account by planters. One London firm has recommended that when shipping crêpe the planters would be well advised to grade same into three groups; (a) pale and light



F. Holloway.
HOLLOWAY'S LACE RUBBER MANUFACTURE.

amber coloured; (b) light coloured scrap; and (c) brown or black crêpe. In reply to a circular letter, in October 1907, Messrs Gow, Wilson and Stanton stated that paleness was very important and pale or clear, even, amber-coloured rubber would sell best; Messrs S. Figgis and Co., at a later date suggested that plantation rubber should be graded according to colour and shipped as (a) pale and clear; (b) brown coloured; (c) dark brown coloured.

BLOCK RUBBER : METHOD OF PREPARATION.

During the latter part of 1906, after block rubber had received special recognition at the Singapore Agri-Horticultural Show and the Ceylon Rubber Exhibition, I received the following communication from Mr. Francis Pears, which was immediately sent to the Press, from Lanadron Estate :—

“ Seeing the attention this has attracted both at the Singapore Agri-Horticultural Show and at the Ceylon Rubber Exhibition, it would not seem out of place to fully explain the points in its favour and the details of its inception, as claimed by the makers. The Prize “Block” was manufactured by the Lanadron Estate of Muar and the awards made by the Judges of both Exhibitions are fully confirmed by the buyers at home who value this method of preparation at 3 pence per lb. higher than the best sheet or crêpe. This will, of course, have the effect of inducing many planters to take up this method of preparation, and it is to be hoped that in doing so they will recognise that it requires good machinery and that good “Block” is not to be manufactured by immersing sheet or biscuits in hot water and hydraulic pressing. This would only imitate it in appearance and not in quality. The manufacture of “Block” by the Lanadron Estate was conceived, in the first instance, as a means of turning out a rubber of standard uniformity in a practical manner, and one which would commend itself to those manufacturing rubber on a large scale; also to be a handy form for shipping and for storage at home. That this has been accomplished must be apparent to everybody. Added to this the improvement in the quality undoubtedly establishes this as the best means of manufacturing raw rubber hitherto employed. In considering any new methods referring to the treatment of raw rubber, there are certain axioms to be considered, the most important of which are the following :—

1. Uniformity.
2. The eradication, as far as possible, of organic, and the complete removal of inorganic, impurities from the latex
3. Acceleration during manufacture to reduce to a minimum exposure to the air.
4. Small surface exposed after manufacture.

Rubber manufactured with a view to these principles, besides having the characteristics of a good commercial rubber, will give a system which would appeal to anyone who takes an intelligent interest in this industry and is desirous of establishing a factory organisation on up-to-date principles, and where manual labour will be reduced to a minimum.

1. Respecting uniformity, the only way to accomplish this is to mix the latex and coagulate in bulk. It has been suggested that the latex from trees of different ages should be kept separate, but this proposition is not one that could easily be carried out in practice. It would be much better to start with the uniform standard; and if old trees really do give a superior latex, the product of the estate must gradually improve with age. It has not yet been proved conclusively that the older the tree the better the rubber, although there are many indications pointing to this conclusion.

2. The eradication, as far as possible, of organic and the complete removal of inorganic impurities in the latex:—the only way to effect this, as everybody who is interested knows, is to wash the freshly coagulated latex on an ordinary washing machine, such as manufacturers use at home. In fact it is the only practicable method of reducing coagulated latex in bulk to uniformity of size, at the same time thoroughly washing every particle of rubber and removing all mechanical, besides a good deal of the organic impurities. Tackiness, of which we have heard a good deal lately, and also mildew although of frequent occurrence in biscuits, seldom if ever occur in properly washed crêpe. This is strong testimony to the fact that washing freshly-coagulated rubber removes some of the organic impurities which are detrimental to the keeping properties of the raw rubber. Whether in addition to this it may be advisable to impregnate the latex with some antiseptic, such as smoke (creosote) formaldehyde, etc., is a matter for further experiment.

3. Acceleration during manufacture to reduce to a minimum exposure to the air:—despatch during manufacture can only be accomplished by accelerating the drying process, as hitherto this has occupied periods varying from a few days to as many weeks, with exposure all the time to the action of the air. Vacuum drying is the only practical solution to this as it combines two very essential points, viz.:—rapidity, without an exposure to the air. By this means it is possible to dry the rubber in two or three hours. Exception has been taken to the use of Vacuum dryers, as making rubber sticky, but this is only a matter of temperature which can be regulated mechanically. It is certainly rather a delicate operation and requires a man in charge who thoroughly understands the principles of the machine.



BROWN & DAVIDSON'S BLOCKING PRESS.

4. Small surface exposure after manufacture:—after removal of the crêpe from the Vacuum drier it is in a pliable condition in consequence of not being subjected to the hardening influence of air drying (oxidation). In this state it is easily pressed into any convenient shaped "block" and the whole forms a perfectly homogeneous mass, hermetically sealed, with a minimum surface exposed to the air and light".

In the above de-scription of the method brought forward by Mr. Francis Pears, there are several minor points with which many will be inclined to disagree, but as the object is to draw attention to the blocking process these need not be here dealt with.

The above detailed account may be summarized as follows: block rubber may be made from biscuits, sheets, crêpe, lace, scrap, or worm rubber by pressing the material while in the soft condition as it is in when removed from the heated vacuum chamber, or by pressing freshly-coagulated wet rubber. The blocks may be made into cubes or rectangular slabs and in all cases present only a relatively small surface to the action of the air.

Owing to the arrival of parcels of wet block many manufacturers have shown a disinclination to purchase rubber in this form; many of them have gone back to the old form of sheets or the later form of crêpe.

TENSILE STRENGTH OF BLOCK AND BISCUIT.

Messrs. Clayton Beadle and Stevens, (Chemical News, November 15th, 1907) in their account of the specific gravity of vulcanized, unloaded rubbers, state that the samples of block examined by them yield a vulcanized product of greater tensile strength than the sample of Ceylon biscuit.

SIZE OF BLOCKS.

The original Lanadron blocks were about $10 \times 10 \times 6$ inches. Mr. Francis Pears advocated the preparation of blocks about one cubic foot, so that two could go to a case, with a thin partition between them: such a block would weight about 50 lb. and would therefore be equivalent to about 200 biscuits. The reasons which Mr. Francis Pears gave in support of the idea of making such large blocks were (1) the thinner the blocks the more hydraulic presses required, or less time must be given to pressing each block, and (2) several thin blocks or slabs packed in one case would be firmly stuck together on arrival in Europe and would require considerable effort to separate them. Several London firms, however, have suggested that the blocks should not be so thick and state that rectangular slabs, would be welcome; the thinner blocks are handled with more ease.

BLOCKING DRY RUBBER.

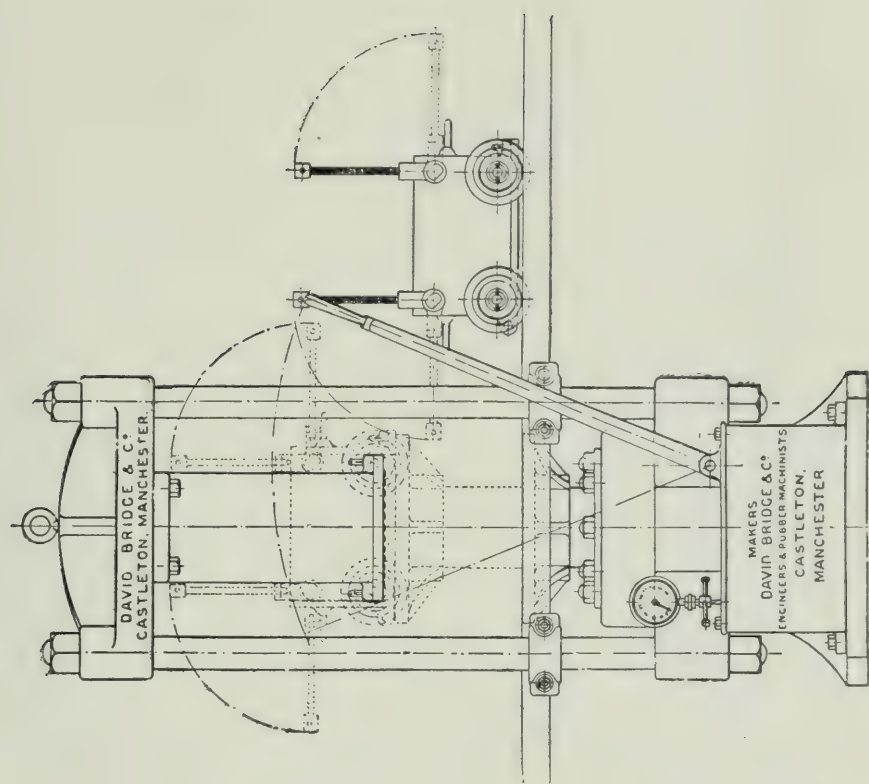
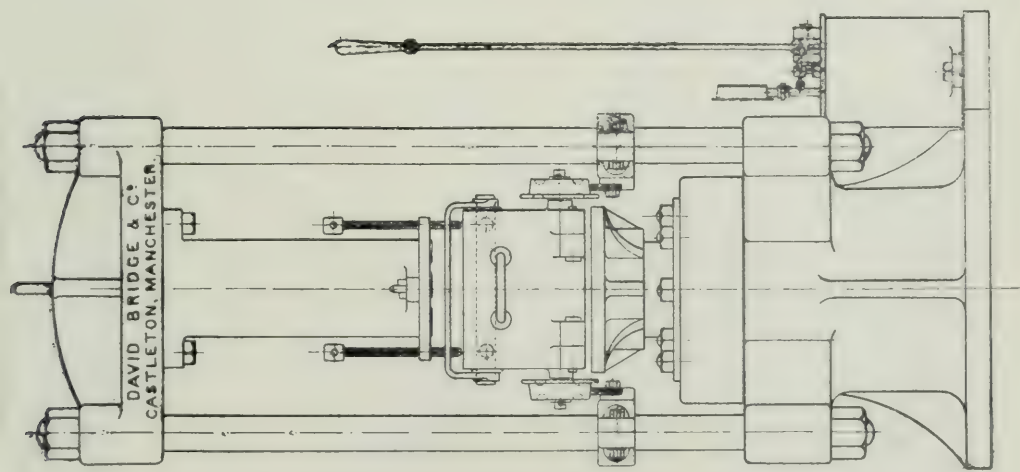
Block rubber can, of course, be most effectively made by pressing the freshly coagulated latex, or the partially dry and soft rubber fresh from the vacuum driers; but it is also possible to make a block by pressing biscuits which have been kept in the dried state for several months. On one occasion some of the Henaratgoda biscuits, ten weeks old and perfectly dry, were placed in a mould and subjected to enormous pressure in a large hand screw press; the pressed biscuits were kept in this condition for two nights and one day—36 hours in all—and then removed; the block was almost as perfect as the best sample sent to the Peradeniya Rubber Exhibition from Lanadron Estate, all traces of the separate biscuits being superficially destroyed and only feebly distinguishable when the block was cut in two. If the dry rubber is passed through heated rollers it is softened and in a condition fit to be blocked.

PRESSES FOR BLOCKING RUBBER.

Freshly-coagulated rubber is soft and spongy and can be blocked without the use of complicated machinery. On some small properties a letter press has been effectively used in the preparation of small samples of slab or block rubber, but on estates where the daily output is at all large, the use of a well-made press is essential for blocking rubber. The presses first brought before the planters were usually so constructed as to be capable of being worked by hand or power, and a large number have already been found to be very defective when required to give a pressure equal to one or two tons per square inch. The use of hydraulic presses is generally viewed with favour and already machinery of this type has been placed on the market. Presses of various types have been tried and a description of some of these will not be out of place.

BROWN & DAVIDSON'S PRESS.

Messrs. Brown and Davidson, Ceylon, showed a wooden screw press at the Ceylon Rubber Exhibition in 1906. Since that time the presses have been improved and in a specification of a hand screw press, given by the above firm in their catalogue of Plantation rubber machinery, it is stated that the (1) press is made of cast iron bolted to the base plate and strongly ribbed up all round the four sides. The cast is in four pieces, all the joints are machined and firmly bolted together and the whole securely fixed to the base plate. One section can quickly be removed for withdrawing the rubber "Block". The four sides of the press are all machined inside and have smooth surfaces so that no part of the rubber touches any rough or uneven part while being blocked. The double motion ratchet gear is made of cast iron, capstan machined all over, bored and fitted to the pressure screw, and is provided with a cast iron socket.



HYDRAULIC BLOCK PRESSES.

The pressure may be applied by the steel hand lever when moved in either direction.

Blocks of 12 in. square by 9 in. to 10 in. in thickness can be made in this machine, but it is often desirable to have blocks or slabs made, 12 in. square by 2 in. thick, more or less.

SHAW'S BLOCK PRESS.

Messrs. Shaw and Co., Manchester, have placed on the market a compact hydraulic press. It is * claimed that, in their press, there are no working parts liable to get out of order, which is a great consideration when the native labour usually employed is taken into account. An illustration of this press is given elsewhere. The top is hinged for charging and emptying, and can be arranged to produce any size of finished block. The three presses of the plant in question are arranged for producing blocks 9 in. square by 3 in. thick. The cavity filled with rubber before pressing being 9 in. square by 9 in. deep. Name plates are supplied to fit the cavities by means of which the name of the plantation is impressed on each block of rubber produced. The press is operated by a small hand pump as shown, fitted with a safety valve which allows the water to circulate as soon as the required pressure is attained in the press. For smaller plants Messrs. Shaw supply machines of smaller construction and made for driving either from line shafting near the floor level, or by means of belting from overhead shafting.

DAVID BRIDGE'S PRESSES.

Messrs. David Bridge and Co., Manchester, have designed a blocking press which can be worked by hand or otherwise. It consists of a screw fitted with a machine-cut worm wheel, driven by a steel-cut worm by fast and loose pulleys. A reversing motion is arranged for the quick withdrawal of the platten.

This is carried on two strong steel columns, bolted to the base. The platten proper has a detachable platten cotted to it, on which are letters for branding the block rubber. The box is detachable, therefore any number of boxes can be used with the one press. Each box is fitted with two strong wrought iron bridles, with four powerful screws. After the crêpe rubber has left the vacuum dryer, it is pressed in the box, and when under pressure, the bridles are brought over to an upright position. The screws are then brought down on the top of the false platten, the cotters are knocked out, leaving the rubber under pressure, and the screws run back clear of the box; the latter is then removed and run on to the lower shelf of the vacuum dryer for a period to set. When quite set, it is

* India-Rubber Journal Sept. 23rd., 1907.

again removed from the vacuum dryer. The bottom of the box, which is hinged, then allows the block to be forced out by the four vertical screws.

This press is also fitted with a hand motion, which is quite satisfactory in the absence of mechanical power. The power required to drive by belt is from 2 to 3 h.p. The boxes are of different sizes. A convenient size is 11 inches by 9 inches, and the thickness of the block is about $4\frac{1}{2}$ inches. The total weight of this press is about 17 cwt., with one box, and it can be dismantled so easily that there is no difficulty in transporting the various parts to their destination.

The press can also make a block of any thickness from 1 in. to 6 in. depending upon the first packing of the crêpe in the box.

BRIDGE'S HYDRAULIC RUBBER BLOCK PRESS.

Messrs. David Bridge & Co., of Castleton, have patented a hydraulic rubber block press which appears to be useful for blocking rubber; by the use of hydraulic pressure a known total pressure can be put upon the rubber being pressed, and the pressure can be regulated exactly in accordance with requirements.

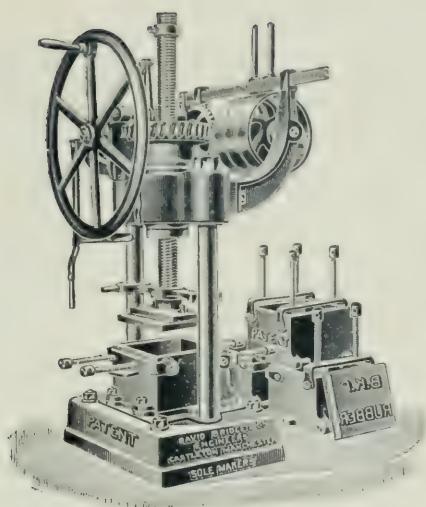
The machine consists of a hydraulic cast iron ram, fitted into a strong hydraulic cylinder, with suitable leather arranged to work at a pressure of 1,200 lb. per square inch. The base of the cylinder is arranged to carry an improved design hydraulic pump, operated by hand lever, with relief valve, and hydraulic pressure gauge.

A strong cast iron rising table is fitted upon the top of the ram, and an extra strong cast iron head, fitted with lifting eye and mullet or ram of sufficient length, secured to same to admit of its passing into the box when placed on the table, and so press the rubber to the necessary thickness. The cast iron head is supported by four turned steel pillars, secured by hexagon nuts to the head and cylinder mentioned.

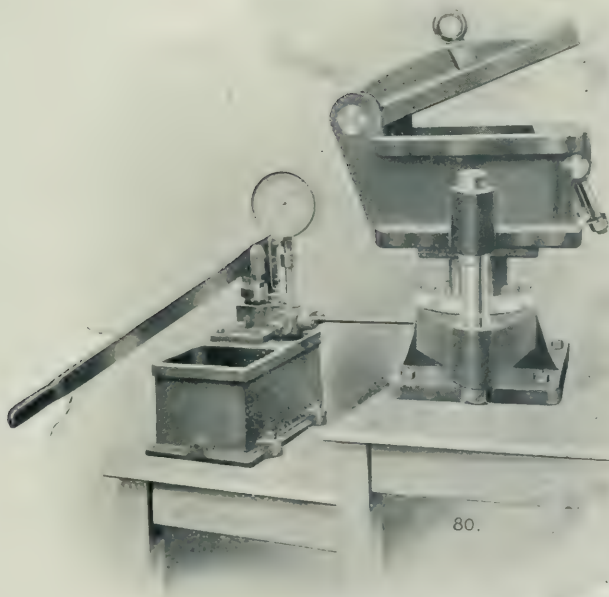
The underside of the mullet is so prepared as to admit of the name plate, for branding the rubber.

The table is arranged to receive interchangeable boxes 14 in. by 12 in. by 9 in., which are fitted with runners on rails secured to the pillars, and quickly run away to any part of the works. Each box is arranged to run on wheels, and fitted with two strong wrought iron bridles, with four powerful screws.

The press can also be supplied, without the hydraulic hand pump, and arranged to be supplied from any hydraulic main that may be already in existence, or separate power-driven hydraulic pump could be supplied, with accumulator for feeding a battery of presses.



BRIDGE'S BLOCKING PRESS.



SHAW'S BLOCKING PRESS.

HAND BLOCK PRESSES.

The total weight of this press is about 45 cwt. with one box.

KINDS OF PLANTATION RUBBER: MANUFACTURERS' ADVICE.

The various forms which have been here described have now been known to manufacturers for several years, and the advantages and disadvantages of each publicly discussed on several occasions.

The "India-Rubber Journal" published the views of manufacturers on this subject in the latter part of 1907, and pointed out that though the experimental phase in the preparation of rubber in various fancy forms was almost past, and block, crêpe, sheet and biscuits were the predominating types on the London market, yet the original biscuits still appealed to certain manufacturers, apparently because they could be easily examined to ascertain their purity; sheet similarly appealed to many manufacturers in virtue of its purity and the fact that it had not been subjected to any mechanical treatment.

As far as the producer is concerned, biscuits and sheets are prepared in the same manner and at the same cost, but they prefer the rectangular form for convenience in packing. Biscuits and sheets, owing to the very long time required to effectively dry them, are not popular, except on small estates where vacuum driers are not in use; the use of any quick-drying apparatus would, however, enable the planters to place their rubber on the market in these forms in a very short interval. To the planter there is another objection against biscuits and sheets: they must generally be prepared in small pans by the slow-setting process, requiring big factory space and a waiting period of over twelve hours, whereas the whole of the day's latex can be converted into rubber in one receptacle in the space of a few minutes. The manufacturers who still prefer biscuits request that these pan-cakes be as thin as possible. Those who prefer plantation rubber in the form of sheets specify that the sheets should be fairly thin: one firm also suggests that they should be two to three feet wide by two to three yards long. Very few of the manufacturers then stipulated that they preferred the plantation rubber to be in the form of crêpe, though they did not, at the same time, emphasize their objections against rubber in that form. It is of interest to note, however, that the two forms which appeared to receive most approval were biscuits and block.

Perhaps when more firms have tried crêpe and block they will give us their opinion of its value. Those who have tried the latter suggest that a convenient size for the blocks would be 6 inches square; all agree in suggesting that the thickness should not exceed $1\frac{1}{2}$ inches and a diameter of not more than $1\frac{1}{2}$ feet.

SMALL LOTS OF RUBBER: BROKERS' ADVICE

According to the "India-Rubber Journal" (Sept. 25th, 1907.) representations have been made regarding the difficulties which

some brokers experience in advantageously disposing of small, classified lots of rubber frequently received from individual estates in the Federated Malay States and Ceylon. Planters appear to be very anxious to keep all grades in separate packets, a principle which should be continued, and against which no objection can reasonably be made. But it is, in the sale room, very difficult to provide space for, and to dispose of, very small quantities of graded rubber to the best advantage as separate lots, and before long it is anticipated that brokers will be compelled to sell such consignments, from each estate, as one lot or accumulate small lots until they have about 1 cwt. of each grade. In one instance there were no less than six grades in a consignment from one estate though the total weight was only 1½ cwt. Up to the present time many brokers have been able to dispose of their small lots in separate batches, according to grades, but now that so many estates are beginning to tap their rubber trees the difficulty may, especially during the next couple of years, become a very serious one. It has been suggested by some brokers that planters would be acting wisely if they agreed to the sale of their small lots as one lot; it would certainly be to the convenience of brokers and buyers. Each small lot could be packed separately, according to quality, and these placed in one box without any difficulty.

Messrs. Figgis and Son are of the opinion that planters might arrange to keep very small lots of the different descriptions till they have at least 1 to 2 cwt. of one kind, as the large buyers will not take very small lots. Should there be several small lots from one estate they suggest that it may be wise to put them together at the auctions so as to induce bidding. As a rule the larger lots sell best.

Messrs. Lewis and Peat point out that they have had great difficulty in advantageously disposing of small lots of plantation-grown rubbers, both from Ceylon and the Straits. They allow that it is only natural that shippers and importers should wish to sell each grade separately and at full values, but contend that very often these small lots only realize comparatively low prices, and are not bought by the big buyers. They suggest that planters should keep back the scrap, rejections, cut pieces and lumps, until they have sufficient of each grade to fill one case of, say, about 1 cwt. at least; the finer qualities could be sent along as usual.

Messrs. Gow, Wilson and Stanton state that a difficulty has been experienced in disposing of very small lots according to their intrinsic value. They suggest that on estates at present producing very small quantities, the manager should keep the rubber in the factory until he has a minimum of, say, about 1 cwt. of each grade ready for shipment. There should be little difficulty in arranging this, and it would be of advantage to the producer.

This suggestion is not so necessary in the case of higher grades of standard sheet, biscuits, etc., small cases of this can often be satisfactorily disposed of to make up orders. With the lower grades, however, the variation is much greater and the value less certain, so that their disposal is more difficult.

Messrs. William Wright and Co., (Liverpool) maintain that if planters wish to realise the full value of their rubber, they will continue to grade each parcel; each grade should, however, be shipped separately. Buyers naturally will not trouble themselves over small quantities; the shippers should wait until they have a reasonable quantity of each grade, and then ship each quality as a separate consignment.

Messrs. Waterhouse and Sons (Liverpool) consider that in the interests of planters and merchants the practice of shipping such small lots is to be avoided, as better prices are invariably paid for fairly good-sized parcels. Presuming it is necessary to keep the grades separate, it would be well if the planters could arrange not to ship any one grade until a sufficiently large quantity could be produced—not less than 1 cwt.

Messrs. Jewesbury and Co. claim that a buyer of clean sheets of biscuits may have no use for the inferior grades of scrap, and buyers of the latter may have no use for the former; consequently if you compel a buyer to take all grades, he will do so only at a price under the market average value. The difficulties, however, to a large extent cease to exist if the planter or importer gives permission to his brokers to sell either in public sale or by private contract, whichever they find the more advantageous. They learn that many manufacturers are experimenting with plantation rubber and are therefore glad to be able to procure small lots of given grades, for which they have been and are willing to pay full market rates; the probable increase in the near future of the number of estates consigning small lots to this market will, according to Messrs. Jewesbury and Co. be fully met by the regularly increasing number of manufacturers who are enquiring for small lots for experimental purposes. The classification of the grades, is in the opinion of this firm, a distinct advantage.

One or two brokers do not see any very serious objection against small lots, but the majority agree that it would be advisable for the planters to keep back small lots of lower grade rubber until they have at least 1 cwt.; this is a recommendation which is, by one firm, only intended to apply to the poorer qualities. Representatives of Ceylon brokers have suggested that they might be prepared to buy up, in Colombo the small lots from various estates, and ship same as one lot when the minimum quantity had been purchased. The accompanying illustration

shows the various kinds of plantation rubber as they are presented to buyers in the auction room on sale days.

ANALYSES OF PLANTATION RUBBER.

The following analyses of the different forms of rubber are tabulated for reference, though a wide variation must be allowed in each case. A general average composition cannot be given until more analyses have been made :—

	Ceylon Biscuits.	Ceylon Lace.*		Ceylon Worms.		Straits Pale Sample.	Crêpe Darker Sample.
		A.	B.	A.	B.		
	%	%	%	%	%	%	%
Moisture	.. 0.85	0.50	0.45	0.90	0.70	0.50	0.52
Ash ..	.. 0.14	0.12	0.30	0.20	0.20	0.27	0.30
Resin ..	.. 2.66	2.68	2.75	3.50	2.06	3.60	3.02
Proteids or Nitro- genous matter	.. 1.75	2.62	2.69	3.85	3.67	2.36	2.56
Caoutchouc	.. 94.60	94.08	93.81	91.55	93.37	93.27	93.60
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

I am indebted to Mr. M. Kelway Bamber for the analyses of biscuit, lace (A), and worm rubber, and to Mr. P. J. Burgess, for the privilege of using the analyses of crêpe rubber from the Straits by Herbert Ballantyne, F.I.C., F.C.S.

* By Ballantyne, in India-Rubber Journal.



CHAPTER XIX.

DISEASES OF PARA RUBBER TREES.

Diseases of plants grown on small areas—Epidemics over large acreages—Checking disease by tree belts—Forest belts in Malaya—Advantages of mixed products—Block Planting—Retention of native compounds between estates—Illustration showing hardy characteristics of *Hevea brasiliensis*—Diseases of rubber plants—Burs, twists, and fasciations—Para rubber pests in Brazil and Java—Pests of nursery plants and stumps—Mites, bees and wasps, beetles, crickets, cockchafer, *Ceratina* species, *Pestalozzia*, grey blight—*Glomosporium*—Leaf diseases of Para rubber—Fungi, *Helminthosporium*, *Periconia*, *Cladosporium*, *Macrosporium*, *Cercospora*—Preventive measures—Fruit diseases of Para rubber—Fungi, *Nectria* and *Phytophthora*—Preventive measures—Stem diseases of Para rubber—Fungi on old stems and green twigs—Preventive measures—Die back—*Botryodiplodia*—*Corticium*—A bark fungus in the Straits—Insects, wood-borers, ants, and slugs—Preventive measures—*Termes Gestroi* and rubber exudations—Extermination of white ants—Borer in Java—Horned termite—Root diseases of Para rubber Fungi in Straits and Ceylon—Fomes in the Straits—*Polyporus*, *Helicobasidium*, and *Hymenochaete*—Insects, termites, cockchafers, grubs—Preventive measures—A disease on prepared rubber—Probable causes & preventive measures—Analyses of black & yellow tacky rubber—Chemical analyses of tacky and sound rubber—Moulds on rubber.

IT is often relatively easy to successfully grow a small number of plants in any particular district without their suffering from the ravages of innumerable insects and fungi. But if the same crop is grown on a large scale matters often take a different turn. It has frequently been my experience when dealing with minor products on a small scale to find that the diseases to which they were subject never developed to a serious extent, but when once the product was greatly extended the insignificant diseases became a serious menace to the plants and often rendered further cultivation impossible.

It would appear on first considerations that any pest, which found a desirable means of sustenance on the tissues of a particular plant, would increase to such an extent that the few host plants in the neighbourhood would be exterminated. But, for some reason or other, many pests do not appear to behave in this manner, and it is only when the host plant occurs in large numbers and over extensive areas that anything like an epidemic is noticeable.

Perhaps the occurrence in large numbers of the host plants in widely separated districts ensures that the pests will find the requisite means of sustenance, no matter where they occur, and their propagation be thereby ensured. The larger their food supply, the quicker they will increase in number and ultimately prove more serious to the crop on which they are living. On these grounds the contention of Colombo friends "that the cultivation of Para rubber to the exclusion of other kinds of rubber is a dangerous system," has probably much to recommend it. On some large estates the Para trees are being grouped, and each group is separated from its neighbour by a belt of forest or of *Castilloa elastica* trees. Such a belt would prevent, to a certain extent, the spread of disease, and one might be able to more easily combat insect or fungus pests, as soon as they made their appearance on the enclosed Para rubber trees.

FOREST PROTECTIVE BELTS.

It has been conclusively proved, to the satisfaction of most tropical entomologists and mycologists, that many of the parasites on cultivated plants have specific or generic hosts; they usually confine themselves to a single species or groups of allied plants. Certain fungi which now thrive on cacao pods do not attack tea plants in the same district; one which attacks rubber plants will probably not damage *Cinchona*; each pest thrives best and often only on a particular product. The pests appear to become established and effect the greatest damage, wherever a very large acreage is occupied by only one cultivated product; wherever the insects or fungi are carried, a fresh source of the same food is at hand, and in consequence of this, the parasites, though blown about for many miles are rarely deposited in areas where a food supply is not available.

A fungus which thrives on coffee leaves and kills them would probably die of starvation if placed on a tea plantation where only tea leaves were available. It may be generally stated that a large acreage uninterrupted with other species affords one of the best means for propagating parasitic species! It is essential that, in order to check the spread of insect and fungus pests, the belts of trees, virgin or planted, shall be composed of species unlike—botanically—those to be protected. For instance, in some parts of Java, the cacao and rubber trees are arranged in separate patches, so that the rows of rubber trees form distinct belts between parallel groups of cacao trees. One plan which has been suggested is to plant five or more lines of cacao, the lines to be 10 to 15 feet apart: interplant these with Dadap shade trees, if necessary, then plant three or six lines of rubber, the lines to be 10 to 20 feet apart. The rubber trees in one line might be all of the same species, but adjacent lines, might, if considered advisable, be composed of different species, say Para, and *Castilloa*.

A belt of jungle not possessing these cultivated trees will arrest parasitic insects and fungi, but may not feed them; if these parasitic organisms are kept from their host plants they are apt to die or degenerate, the belts thus serving as traps.

FOREST BELTS IN MALAYA

The idea that all parasites come from the jungle, and that forest belts may therefore harbour pests, is one which is frequently brought forward by planters, and though one does not find much to support this view it is admitted that the origin of parasites in the tropics is sometimes very problematical. Everyone, however, with tropical experience is convinced that small properties are generally freer from pests than large ones, and that barriers in the form of belts of unlike species assist one in keeping diseases at the minimum. The retention of barriers of virgin forest has been brought into force in the F. M. S. by the Government Botanist; there very large tracks of forest of enormous width are retained between certain districts. In his annual Report for 1906, Carruthers states:

“The value of protective forest belts was explained in the last report and these necessary guards against plant diseases are still occupying my attention, and Government will be asked to continue the policy and reserve more of these belts to cut off various planting districts from each other. Dr. Treub of Java, who is the greatest living authority on tropical agriculture, is much interested in these protective jungle belts; he considers them a sound and wise provision which unfortunately in Java and other agricultural countries it is now too late to lay out as too much land has already passed away from the control of the State.”

This is a system which the Government Mycologist at Peradeniya approved in September last when he stated as follows:—“I should like to express my entire agreement with the suggestion that the Hevea acreage should be broken up into small blocks by belts of other trees. The reservation of forest belts in the F.M.S. is one of the most important advances in disease that have ever been made. There is, unfortunately, no similar policy in Ceylon.”

ADVANTAGES OF MIXED PRODUCTS.

Mr. Green, the Government Entomologist on the same occasion, stated as follows:—“The history of every cultivation has shown that, with increase of area and lapse of time, new pests arise attracted by the altered conditions and an abundant supply of food. Our Ceylon system of exclusive cultivation of single products, though convenient for economic purposes, lends itself to the rapid spread of pests and calls for special measures to meet this liability. Plants in their natural state—where numerous orders, genera and species

are intimately mingled together—are not nearly so subject to the ravages of disease. Apart from the physiological benefits of commensalism—now becoming more generally recognised—the more or less complete isolation of individual species that occurs under natural conditions is itself a check to the extension of disease.”

“These facts lead up to the consideration of what I look upon as by far the most important part of my subject, that of isolation. During the six years in which I have occupied my present position, and the many previous years of practical experience as a planter, I have been impressed with a sense of the immense difficulties that lie in the way of combating any serious insect pests where no efficient means of isolating any particular area for purposes of remedial treatment are present. The task has seemed a hopeless one, and has too often proved an impossible one. What are the conditions that prevailed during the reign of coffee and that are now equally or even more pronounced during the age of tea? We find vast continuous tracts of land planted with a single product, unbroken by either natural or artificial boundaries, and affording no hindrance to the free distribution of any infectious disease. Under such conditions how can we hope to effectively deal with our insect enemies? Vigorous measures may be employed and a pest may be temporarily exterminated on a limited area; but the disinfected parts are immediately liable to fresh invasions from all sides. Given an isolated field we can deal with a pest with some confidence that our labour will not be nullified. I would most earnestly urge our rubber planters to take warning from the mistakes that have been made in the cultivation of the older staple products of Ceylon.”

“The remedy lies in the formation of protective belts or boundaries of either jungle or cultivated trees. Such belts should be at least 30 feet in depth and composed of close growing trees with a good cover of foliage. As in most trees the lower parts are bare of foliage, a separate undergrowth will be necessary to ensure an effective screen. It is also important to understand that the trees and shrubs composing the belts should be of kinds differing as widely as possible from the plants that are to be protected by means. Insects, though seldom dependent upon a single species of plant for their nourishment, generally confine their attention to distinct groups of nearly related species and genera. If the protective screens are composed of trees belonging to a distinct natural order, there is much less chance of the inter-communication of pests. It is not in my province to decide what particular species should be employed for the purpose. That is a matter that must be determined by the botanists, and will be affected by considerations of climate and altitude. The anticipated profits from a single rubber tree are so great that proprietors are tempted to plant up every available spot and are unwilling to allow a single

yard of suitable soil to be occupied by what they would consider to be unprofitable growths. This is surely a very short-sighted policy; but to meet their view I would suggest that screens composed of other species of rubber—for example—Rambong and Castilloa—might be interposed between adjacent fields of Para rubber. Both Rambong (*Ficus elastica*) and Castilloa are members of the family Urticaceae, while Hevea belongs to the distinct family Euphorbiaceae. We do not, at present, know very much about the productiveness of these two kinds of rubber in Ceylon, but any yield that they may possibly give should be looked upon as pre-requisite, their true value being as a means of insulation to the more valuable Hevea plants. I may mention that the Ceara rubber is a close relative of the Hevea, and is consequently unsuitable as a component in the protective screens. As an undergrowth—in combination with Rambong and Castilloa—tea and coffee might be tried, or some plant the clippings of which might be employed as green manure. Cinnamon would make an almost ideal screen as undergrowth.”

BLOCK PLANTING.

It is not necessary to apologise for such a lengthy extract from the remarks made by Mr. E. E. Green as the subject deserves more consideration than it has yet received from eastern officials and planters. In order to meet the views herein expressed several African and American rubber planting companies, dealing with the cultivation of several species in the same territory, have caused the trees to be planted in blocks so that the continuous area under each species is limited and the trees are surrounded by unlike species. This block system of planting can easily be carried out when the estates are first taken over.

When touring through Ceylon in April, 1908, the writer observed that many strips or patches of native compounds planted with species other than those yielding rubber, were retained; these serve to isolate the large rubber estates in the same district from one another and their preservation should, if possible, be encouraged.

DISEASES OF RUBBER PLANTS.

Much has been written on the subject of plant diseases in the tropics, and Government have, from past experience seen the necessity to appoint officers to investigate the life histories of pests as soon as they appear. Every cultivated plant in the tropics is subject to the attacks of injurious insects and fungi, and we are now in possession of up-to-date information which enables planters to suppress most parasitic diseases as soon as they appear. The first appearance of a pest in the tropics is usually promptly notified by the authorities, every publicity is given to even the harmless forms, and planters and investors are now fully alive to the importance of carrying out well-advised plant sanitation operations.

The conditions under which rubber plants are sometimes grown appear to be favourable to the spread of diseases, but it is satisfactory to know that effective remedial measures can be applied against most of the pests known to affect cultivated rubber plants.

It is, however, well to realize that trees of Para rubber, whether growing under unhealthy or perfect conditions, are not immune from the attacks of parasitic fungi and insects, even at a time when the number and age of the host plants may seem to be almost negligible. The best advice which can be given is to attack all diseases in their earliest stages before the parasites have increased beyond easy control. It is fortunate that among the many diseases or pests mentioned below most of them are not of a very serious nature, but they are nevertheless worthy of full consideration. Only the more important pests are dealt with in these notes.

BURRS, TWISTS, AND FASCIATIONS.

Unusual growths which cannot be associated with any pests often appear on healthy Para rubber trees.

Sometimes the trees are irregular in outline in consequence of having been exposed to wind, the surface facing the wind frequently being flattened; such trees when twisted are not as easy to tap as those with normal stems.

Burrs or rounded woody knots are frequently observed projecting from the bark, each fitting into a depression; they occur on many of the Henaratgoda trees which were, many years ago, tapped on the V system. These burrs, though they make tapping operations difficult, do not seriously affect the vitality of the tree: they are sometimes associated with bad tapping or bruises but are also often derived from dormant buds.

Fasciated stems have also been recorded but these do not appear to be due to parasitic fungi or insects.

PARA RUBBER PESTS IN BRAZIL AND JAVA.

Hennings* has described and figured five leaf fungi, viz., *Phyllachora Huberi*, *Dothidella Ulei*, *Aposphaeria Ulei*, *Ophiobolus Heveæ*, and *Parodiella Melioloides*. These have been found in Brazil, but do not seem to be very serious, though the *Ophiobolus* is said to destroy the leaf and is perhaps the most dangerous of them.

On sick and rotten trees of various species of *Hevea*, *Allescheriella uredinoides* was found.

In Java, Zimmermann has recorded in the Bull. Inst., Buitenzorg, several fungi on Para rubber. *Phyllosticta Heveæ*, Zimm., is a fungus causing brown spots especially at the tips of

* Notizblatt des Königl. Botanische Gartens und Museums zu Berlin (Vol. 4, No. 34, p. 133).



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FASCIATION OF PARA RUBBER TREE STEM.

the leaves; (*Oleosporium elasticæ*, Cooke and Mass., is another leaf fungus which produces light greenish spots and masses of reddish spore

NURSERY PLANTS AND STUMPS.

Insect Pests.—“Mites” in rubber nurseries have also been reported from the Straits.* Arden states that in some cases the young leaves fall from the plant before they are fully developed, and in other cases the mature leaves present a crinkled appearance, are yellowish-green in colour, and appear to be dotted with numerous punctures. He compares it to “Red Spider,” and believes that the disease is mainly limited to plants growing under unfavourable conditions.

Mr E. E. Green has the following notes regarding pests which are associated with the stems, in the Tropical Agriculturist, February, 1906:—

“The cut ends of young *Hevea* stumps are frequently tunnelled by various small species of bees and wasps. But these insects are not responsible for the dying back. The pith of any dead stem would be utilized in a similar manner.”

“When a *Hevea* plant is stumped it usually dies back to the node, and it is in such dried ends that the tiny wasps construct their nests. They cannot be regarded as pests, but more properly as friends, for most of them provision their nests with Aphides taken from some other plant. Specimens of a small Longicorn beetle, said to be responsible for the death of young *Hevea* rees, have been received from Southern India. The insect proves to be *Pterolophia annulata*, Chev., a species that occurs in Ceylon also. I have no records of injury done by this insect to Para rubber in this country, but I have bred out a specimen from the diseased bark of a Ceara rubber tree. My correspondent from India reports that the beetles girdle the stems; the upper parts of the trees dying back down to the injured area. This girdling habit is common to many species of Longicorn beetles. The object of the manoeuvre is believed to be to check the sap and induce the degree of decay best suited to the nourishment of the grubs of the beetle; the eggs having first been inserted in the bark above the point of injury. If this pest should become common, it might cause serious damage on rubber plantations. In case of any occurrence of the pest the stems of all the trees should be carefully searched. The adult beetles will probably be found clinging to the bark of the trees, when they can be easily captured and destroyed.”

Crickets have been described as biting off the tips of rubber seedlings, by Ridley (Agr. Bull. No. 3., March, 1906) and

* Stanley Arden, Agr. Bull. of the Straits and F.M.S., June, 1905.

Waterhouse of the British Museum has identified some of these pests as *Brachytrypes achatina* and *Gymmogryllus elegans*.

The grub of the large Cockchafer (*Lepidiota pinguis*) appears to be troublesome on young Para rubber plants; Green reports over 3,000 plants being killed in a single clearing. In some cases the tap root has been eaten right through. If the soil is dusted with Kainit, Nitrate of Soda and "Vaporite" the grubs can sometimes be kept in check.

Green, in a recent issue of the "Tropical Agriculturist", reported upon a small bee, found in the centre of stumped Para seedlings. The bee was a species of *Ceratina*, the tribe usually making their nests in the pith of dead branches; if the stumps are cut back to a point just above a node in the stem the bee will probably not be able to build its nest in the pith. Green states that the following species have been observed to infest young rubber plants:—*Trypoxylon intrudens* and *T. pileatum* (provisioning their nests with spiders), *Stigmus niger* (with Aphides), *Odynurus sichelii* (with small caterpillars), *Ceratina simillima*, *C. viridissima*, and *C. propinque* (with bee-breed).

Specimens of a Longicorn beetle (*Moechotypa verrucicollis*, Gahan.), said to have killed young rubber stumps, have been reported upon by Green (T. A. August, 1906).

The bark of the plants had been nibbled off, and the bare wood exposed. Examination of the roots proved that they had previously been attacked by the parasitic fungus, *Botryodiplodia elastica*, Petch. Green further states that this fungus attacks the collar of the plant; kills the upper parts by cutting off the supply of nourishment; and may work down into the root.

Fungus pests a species of *Pestalozzia*—identical with that which is associated with the "grey Blight" on tea leaves—has also been found by Petch on leaves of nursery seedlings of *Hevea*, and according to that mycologist were probably infected by wind-blown spores from the adjacent tea. The fungus produces white irregular areas spreading generally from the tip of the leaf. In the Straits* the leaves of the Para rubber seedlings have been attacked by a fungus, regarding which Mr. Massee reported: "The pale blotches on the leaves are caused by some species of *Cercospora*, but the absence of fruit prevents specific identification." Ridley states that this leaf fungus is common all over the Malay Peninsula, but that except in the case of seedlings does not do much harm.

Petch has recently found a species of *Gloeosporium* on the leaves of seedlings; the fungus forms light brown spots on the upper surface of the leaves, and finally the latter turn yellow and fall.

* *Agriculturist Bull.* of the Straits and F.M.S., July, 1905.

Grey blight on the stems of seedlings has also been observed by Petch. The fungus forms a white zone about an inch long just above the surface of the ground. The stems lose their pith, become hollow, and the plants die.

LEAF DISEASES.

There are already several insects and fungi which live on the leaves of the Para rubber trees, but none of them are very harmful. To a very limited extent the annual fall of leaf that takes place on all Para rubber trees after they have passed their second or third year is an advantage when dealing with leaf pests, as the foliage can be easily and regularly collected and burned. Again, the leaves may happen to fall prior to the formation of the spore-producing bodies, and in this way assist, to some extent, in checking the spread of disease. But it should be remembered that the Para rubber trees are in possession of their foliage for about 50 out of every 52 weeks each year, and to assume that the leaves, owing to their deciduous character, are not likely to contract a permanent disease is by no means sound.

Fungi.—Leaves of Para rubber seedlings and of older plants have been attacked by aspecies of *Helminthosporium* ;* the leaves were “studded with circular, semi-transparent spots, each surrounded by a brown cushion from which arose the threads of the fungus.” It was suggested that the spots were due to punctures by insects and the fungus grew on the dead tissue. Damaged parts of the leaves of Para seedlings are also subject to the attacks of *Periconia pycnospora*,† and species of *Cladosporium* and *Macrosporium*.

It is satisfactory to know that, up to the present time, the leaves of mature Para rubber trees are practically free from parasitic fungi, but the disease on the leaves of seedlings is one which leads to partial defoliation and checks the growth of the young plants. In all such cases the diseased leaves should be pulled off and burnt and the rest of the plants sprayed with Bordeaux mixture ; this consists of 6 lb. of copper sulphate and 4 lb. of freshly-slaked burnt lime in 45 to 50 gallons of water.

Insects.—According to Green‡ the leaves of *Hevea* are reported to have been punctured by certain plant-sucking bugs, the most likely species being *Leptocoris acuta* and *Riptortus linearis* ; the former is known as the “Rice-sapper.” It appears that these pests puncture the leaves and stems. “The injured leaves show numerous small spots, each bordered by an irregular dark rim, within which the tissues have dried and turned white.” It is believed that the injury to the leaves is due more to a fungus than to an insect.

* T. Petch, *Mycological Notes*, *Tropical Agriculturist*, June, 1905.

‡ E. E. Green, *Entomological Notes*, *Tropical Agriculturist*, April and May, 1905.

A scale bug—*Lecanium nigrum*, Nietn.—has also been observed by Green on the leaves of young Para trees, but this can be easily destroyed by means of Macdougall's mixture. The tips of seedlings occasionally turn black and dry up, and it has been suggested that this may be due to some plant-sucking bug. A species of weevil, allied to if not identical with *Astycus lateralis*, has been known to eat the leaves of Para rubber in the Straits,* and the only remedy is to collect and destroy the weevils.

Green has also recorded in the T. A. and Mag. C. A. S., December, 1905, a new species of scale bug (Coccid) upon the leaves, belonging to the genus *Mytilaspis*, but he considers that it is unlikely to cause any serious trouble.

Spotted locusts have also been reported to do considerable damage to the young rubber plants in Ceylon and the Straits.

Locusts have been reported from various districts in Ceylon, and are said to destroy the seedlings and also the leaves of mature plants. According to Green (Tropical Agriculturist, November, 1905) poisoned baits have been found effective in such cases, one of the best being "Arsenic salt horsedung" mixture, made by compounding one part of Paris green or white arsenic with two parts salt and forty parts fresh horsedung. It is recommended that this should be broadcasted among the affected plants or wherever the locusts may be noticed.

FRUIT DISEASE.

Para rubber planters in many parts of Ceylon have occasionally been alarmed at the curious behaviour of certain fruits; some dry up and remain attached to the twigs, and others of all ages fall to the ground without expelling the seeds. The fall of the unexploded fruits is often due to wind, and there is no parasitic fungus to be found in the tissues. It has been stated that the fruits are subject to the attack of a parasitic fungus belonging to the genus *Nectria*, and Carruthers‡ reports having successfully inoculated Para rubber fruits with this fungus, but was not certain as to whether it attacked the fruits when on the tree or only when they fell to the ground. Petch§ subsequently stated that the disease on Para rubber fruits is due to a parasitic fungus similar to, if not identical with, that which causes the decay of cacao pods. All the *Hevea* fruits examined are attacked by a species of *Phytophthora*, which permeates the soft outer tissues of the fruits; the seeds dry up later when the supply of food and water is cut off. In addition to the ordinary spores which infect

* Wray, Perak Museum Notes, 1897.

‡ J. B. Carruthers, Circular R.B.G., Peradeniya, January, 1905.

§ T. Petch, Mycological Notes, Tropical Agriculturist, 1905.

other fruit while the original fungus is flourishing, resting spores are formed in the dead fruit. These are liberated when the fruit decays, and thus serve as a source of infection to the following crop. In this way the fungus bridges the gap between the crops

The most effective way of fighting the fruit disease is to collect all dried fruits which are on the trees and those which have fallen to the ground and burn the lot on the spot. On the average rubber estate there can be no real objection to burning such small quantities of fruits as this treatment involves.

STEM DISEASES.

Fungi.—In his account of canker (*Nectria*) of Para rubber Carruthers points out that a parasitic fungus occurs on the stems and branches, which may prove fatal to the trees. The area attacked by the fungus can be detected often by the change in colour of the bark or by the exudation of the latex. When, however, the fungus has got a firm hold of any local patch of tissue, the latex tubes become quite empty and dry up, so that it not only threatens the life of the tree, but also robs the planter of the latex or rubber for which the tree is being cultivated. It is necessary that all cankered areas should be excised and the tissue burnt on the spot. All the discoloured areas should be removed, even if the woody tissues below the cambium are permanently damaged in the operation. In some cases it is true that the cankered area is, by means of a layer of cork, prevented from extending to other parts of the stem, but it is unwise to leave the matter to chance.

The disease mentioned above has been found by Carruthers on "almost all parts of the tree except the young branches and the roots," but even these parts have now been shown to be attacked by other fungi.

Petch* has observed a blackening of green stems of Para rubber trees to be due to a fungus which produces a network of dark-coloured threads on the exterior.

The "die-back," according to Petch (Annual Report, 1906), continues to kill off trees about a year old. "The stem, usually near the top, turns brown, and ultimately dries up. If the diseased part is allowed to remain, this condition travels down to the base and kills off the tree altogether. The affected part should be cut off and burned. The fungus on the diseased area is *Gloeosporium alborubrum*, Petch."

In his Annual Report for 1906, Petch states that young plants have often failed to grow after being planted out. "In all cases *Botryodiplodia elastica*, Petch, was found to have attacked the

* T. Petch, Mycological Notes, Tropical Agriculturist, August, 1905

plant at the collar, and the same fungus was found on stumps which died under similar conditions in Burma. It probably enters the stem through injuries made during planting. Where it occurs basket plants should be used, or seed planted at stake." He also points out that there seemed some probability that this fungus was identical with *Diplodia cacaoicola*, Henn., which is parasitic or saprophytic on cacao, but on this matter no definite opinion can be given.

A bark fungus has been described in the Straits Agricultural Bulletin,* November, 1905:—"This fungus takes the form of a pinkish-white mass, coating the bark irregularly so as to have an appearance often of hieroglyphics. Attacking usually the upper branches or occasionally the stem, it quite destroys the bark and causes the death of the wood beneath. Fortunately it is easy to see from its conspicuous whitish colour, and easily dealt with by destroying infected branches, and in the case of the trunk being affected by scraping it off and treating with copper sulphate and lime."

This is apparently the omnivorous fungus previously recorded from Java by Ch. Bernard (*Teysmannia*" 5, 19 and named *Corticium Javanicum*, Zimm). It destroys the bark, killing small branches and causing "canker" on the larger. It has also been recorded in Ceylon and South India.

Insect pests.—Ridley has reported the existence of a borer which may attack the wood of Para trees, and identified it as belonging to the genus *Platypus*.

Ants† attack the incised areas six feet from the ground, and in some cases construct earthworks up to a height of 30 to 40 feet and enter the tree at some weak point or wound area. The white ant—*Termes gestroi*—is reported to be one of the most troublesome pests in the Federated Malay States. Arden, when dealing with the loss of Para rubber trees in the Straits, points out that there may be some association between the ravages of the white ants and the fungus of the roots of Para rubber. Similar relationships have been suspected in Ceylon,‡ where the taproot had probably been eaten by white ants and the dead roots were covered with a network of white fungus hyphæ. "The fungus attacked the sound wood and bark, and that the injury was due to this was supported by the receipt from another locality of a young plant which had been killed by apparently the same fungus. In this case there were no side roots; the plant therefore died after the taproot had been permeated by the fungus, and as this was indicated by the withering of its leaves, it was uprooted before the white ants discovered it."

* Straits Agricultural Bulletin, November, 1905.

† Stanley Arden, Annual Report, 1902.

‡ T. Petch, Mycological Notes, Tropical Agriculturist, October, 1905

TERMES GESTROI AND RUBBER EXUDATIONS.

Para rubber trees in Borneo, Strait Settlements, and India also suffer from the attacks of *Termes Gestroi*. The termite appears to be quite as destructive when the rubber trees are growing on grass land, or among "lalang" as on clear weeded properties. The insect mainly works its destruction in the dark and gradually hollows out the trunk of the tree, the branches begin to die and the tree is usually blown over during windy weather.

Stebbing* has published an interesting account of the termite pest in India and two species of the Termitidae, *T. Gestroi* and *T. Annamensis*, desn., have been shown to be associated with trees of *Hevea brasiliensis*. A fanciful and erroneous idea has obtained a footing that *Termes Gestroi* "attacks the tree for the purpose of obtaining rubber from it, for, on applying pressure to the bodies of the termites, it was found that the majority of them were full of fresh latex. They apparently collect and store the rubber, masses of rubber being found as a rule in the nests, which are usually situated at the crown of the root. From one of these nests situated at the base of a three-foot girth tree as much as 2 lb. of rubber was collected". It has, however, been pointed out by Ridley† & Green‡ that the insect exudes from its mouth a milky substance, like latex in appearance, for protective purposes; it has also been suggested that the latex may have exuded from some injury or from part of a diseased tree and trickled down to the ants' nest.

EXTERMINATION OF WHITE ANTS.

Planters and officials have made repeated attempts to eradicate Termites ("white ants") and though carbon bisulphide is a most effective means of destroying the insects *in situ* in their subterranean nest it has not yet been largely used. The extended application of this treatment has been handicapped by the impossibility of obtaining a sufficient quantity of the fluid at a reasonable cost. The suggestion that carbon bisulphide might be manufactured in the tropics has now been taken up and Green (Annual Report, R. B. G., Ceylon, 1906) announces that "In the meantime what promises to be a still more convenient and equally effective fumigating apparatus has been perfected and has been in use in South Africa. I have obtained one of these machines and am now conducting experiments, which lead me to believe that a really satisfactory means of exterminating white ants is now at our disposal. The treatment consists in the volatilization of a mixture of sulphur and arsenic. The deadly fumes are driven by a powerful air pump into the galleries of the nest, permeating every part

* E. P. Stebbing, *Indian Forester*, Vol. XXXII, 1906.

† H. N. Ridley, *Agr. Bull. of the Straits and F. M. S.*, April, 1906.

‡ E. E. Green, *T. A. & Mag. C. A. S.*

of it, as evidenced by the issue of jets of smoke from unsuspected apertures for several yards round the main shaft. The apparatus is small, light and comparatively inexpensive, being placed on the market in South Africa at the price of £4 sterling."

Ridley reports an attempt to drive the termites away by filling the holes with cement, which though successful in the instance referred to, does not appear to have been repeated.

Hevea brasiliensis has been attacked by a borer in Java,* the report being to the effect that the insect proved fatal to a seven-year-old tree. The trunk had part of its wood exposed and pierced by numerous little holes. It is suggested that the borers were Scolytidae.

Green also records (T. A. August, 1906) a case of infestation of the stem of a *Hevea* tree "by the 'horned Termite' (*Termes inanis*). This species of termite takes advantage of any hollow in a tree for the construction of its nest, but does not apparently feed upon the wood itself." Though the termites occupied a large cavity in the bole of the stem, the tree continued to live.

Green states that he has repeatedly received specimens of *dead* branches and stems of *Hevea brasiliensis*, perforated by a Bostrichid beetle (*Xylopertha mutilata*, Wek.), but he believes that in every case the beetle has effected its entrance after the death of the parts.

Slugs† (*Limax* spp.) have also been reported as attacking the stem and eating the remains of the latex left in the wounds after tapping. "Living specimens of the slugs received at Peradeniya were fed with fresh latex. Its presence was almost immediately scented out by them. One of them drank for about ten minutes." Hand-picking or the use of quick-lime should be effective.

ROOT DISEASES.

Fungi.—A root disease due to a fungus has already been mentioned as occurring in the Straits and Ceylon in association with white ants, but probably preceding them. Petch has shown that the Ceylon fungus can spread underground on roots of grasses, &c., and that it is a species of *Polyporus* (*Fomes semitostus*, Berk). The hyphæ are described as occurring on the first six inches of the trunks as well as the roots. Any trees so affected should be isolated by digging a deep trench round them about a foot wide, as in the case of the root disease in tea, and, if possible, the diseased specimens should be uprooted and burnt.

* Bulletin du département de l'Agriculture aux Indes Néerlandaises, VI, p. 46.

† E. E. Green, Tropical Agriculturist, Sept., 1905.



FALLEN TREE.

TAPPABLE VERTICAL SHOOT.



A DIVIDED TREE.

THREE TAPPABLE STEMS.

Photo lent by A. O. Devitt, Esq.

ILLUSTRATIONS SHOWING HARDY CHARACTERISTICS OF HEVEA BRASILIENSIS.

The *Fomes* fungus, affecting the roots of rubber plants in the Straits, is described as follows in the Agricultural Bulletin of the Straits and F. M. S. for May, 1904 :—

“ The fruiting part of *Fomes semitostus* is a broad, flat, rounded plate often very irregular in form, usually reniform 4 to 6 inches across, and of an orange-red colour beneath, paler above, where it is marked with rings and fine striae ; beneath can be seen with a lens the honeycomb-like structure of the hymeneal surface. The texture of the fungus is tough, and it possesses a strong mushroom-like scent.

“ This fungus is very common on decaying stumps of all kinds of trees and is, properly speaking, a dead wood feeder, but like a number of allied species attacks also living trees.

“ As a disease fungus I would class this as contagious, as opposed to an infectious fungus, as it appears to spread from root to root in the ground without being dangerously dispersed through its spores. A dead stump may be attacked above or just below the ground, and the mycelium spreading along the decaying roots may come into contact with those of a living tree, and so the attack is spread. These contagious fungi are more easy to deal with than the infectious ones of which the spores are blown from tree to tree and attack the plant where they alight (as in the fungus previously described). The infected trees should be destroyed and the roots dug out, every bit of dead root or decayed timber being removed and the ground well saturated with copper sulphate and lime.

“ Tubeuf, in writing of a similar parasite in Europe (*Fomes an-nosus*) whose habits are very similar to those of *F. semitostus*, states that the best way of combating the ravages of the parasite is isolation of infected areas. These should be isolated by ditches with vertical sides deep enough to cut through all roots, care being taken to leave no diseased stems or roots outside the circle. After remaining open for a time the ditch must be filled again with soil to prevent the formation of sporophores on the exposed roots. All diseased stems should be felled and burnt, or deeply covered with soil to prevent the formation of sporophores ; in fact, isolation of these contagious parasites should be done by ditches in the same way as the infectious parasites are isolated by screens of trees of another species.”

In the opinion of Mr. H. N. Ridley, Director, Botanic Gardens, Singapore, this is one of the most important diseases in the Straits on Para rubber, and deserves prompt attention.

As Messrs. Ridley and Derry have pointed out, this fungus, the mycelium of which is underground, is the worst feature against close planting, as under such conditions it might spread very rapidly.

The uprooting of all dead stumps of trees would appear to be necessary if this disease is to be kept in check. The removal of the jungle stumps would be very effective, if it were economically possible.

A fungus (*Helicobasidium* sps.) has been found attacking the roots of Para rubber in the Straits.* This fungus usually spreads rapidly from tree to tree by means of strands of mycelium; trenching and liming are generally recommended as preventive measures.

Another root disease has been found in Ceylon by Petch.† This one has also been found on cacao, tea, and *Caravonica* cotton in Ceylon, but is not very dangerous. "The roots are covered with a thick yellowish-brown felt which sometimes develops a black crust exteriorly. Stone, sand, &c., are firmly attached to this covering, and give the appearance of pudding-stone." It is believed to be a species of *Hymenochaete*.

Ridley‡ has recorded the occurrence of a subterraneous fungus on the roots of Para rubber trees in Borneo and Perak. The fungus exists as a white mycelium on the roots of the trees under two years old, and spreads to the base of the stem. The behaviour of the fungus suggests a similarity to that of *Fomes semitostus* and in the opinion of Ridley may be one of the *Polyporeæ*. Ridley recommends that the soil should be limed and rubber trees should not be planted on the affected area, but plants of the Banana may, perhaps, be grown in order that the decomposed and infected wood and roots in the soil may be broken up; trap crops might, perhaps, be useful under such circumstances.

The "brown root" disease, which attacks cacao, castilloa, *Hevea* etc., seldom kills out more than one plant, though it attacks practically everything according to Petch (Annual Report 1906.) It can be distinguished by the thick coating of sand and stones which adheres to the mycelium on the root. "It appears to be identical with the mycelium attributed to *Hymenochaete* in Samoa and to *Sporotrichum* in Java; it is probably the same as the *Irpex flavus* of coffee. *Hevea* is more often attacked when planted amongst cacao, or in old, cleared cacao land."

Petch advises that the trees, thus affected, should be removed as soon as they are dead.

Insect Pests.—"Specimens of Termites§ (*T. redemanni*) have been sent with the report that they were eating off the tap roots of young

* Johnson, l. c. p. 29.

† T. Petch, Mycological Notes, Tropical Agriculturist, October, 1905.

‡ Agr. Bull., No. 3, March, 1906.

§ E.E. Green, Entomological Notes, Tropical Agriculturist, April, 1905.

rubber plants. A mixture of lime and sulphur, forked into the soil immediately round the plants, has been found effective in preventing the attacks of white ants. The proportions are one part powdered sulphur to four parts of lime. In replanting, the holes should be filled with earth mixed with lime and sulphur in the proportion of one basket of sulphur, four of lime, and seven of soil. This should protect the new plants from any underground attacks.

Grubs of the large cockchafer (*Lepidiota pinguis*, Burm.) have been received by Green* from Yatiyantota, Ceylon, with the report that they are found about two inches below ground-level. "It is stated that the pest bites through a live stump (of Para rubber) of any size. The only way one can tell that it is working is by seeing the green shoot on the stump die back. On touching the stump it breaks off. Specimens of injured stump (of about the thickness of a lead pencil) were sent in with the grubs. The taproot has been severed an inch or two below the collar, and every vestige of a side root has disappeared. Alkaline manures, such as kainit and nitrate of soda, have been found useful in driving away cockchafer grubs. The manure should be forked in round the plants in clearings affected by the pest. The same species was recorded in 1902 from the Negombo District, where it attacked the roots of cinnamon bushes. The adult beetle is of considerable size, being fully an inch long and proportionately stout. The larva is a white fleshy grub, two inches in length, the body curved round into the form of a horse shoe. It has very powerful jaws, with which it works great havoc on the roots upon which it feeds."

"A formidable looking grub of some large beetle (Buprestid or Longicorn²) has been sent by a correspondent from Ruanwella. It is said to have been found in the taproot of a rubber tree that had died and broken off. The pest in its larval stage, working—as it does—below ground-level, will be difficult to attack."

A DISEASE ON RUBBER.

It seems as though enough has been said regarding the troubles of all parts of the plants with fungi and insects, but this note deals with a disease on the prepared rubber and cannot be omitted. The signs of the disease are that the rubber becomes at first sticky or tacky, and rapidly softens until it is almost liquid. It can be spread from one biscuit to another by contact. It is supposed to be due to bacteria, which first commence to grow on the sugary and gummy substances in imperfectly washed rubber and ultimately on the decomposing protein or albuminous material previously referred to. It can to a great extent be kept in check by well washing and squeezing the freshly-coagulated rubber, rapid drying without exposure to

* E. E. Green, Entomological Notes, Tropical Agriculturist, October, 1905.

high temperatures, and the use of formalin in the latex and on the prepared rubber. Mr. Kelway Bamber recommended that the biscuits be wiped with a solution of formalin, diluted to make a 2 per cent. solution, and not be allowed to touch one another earlier than necessary.

The following are analyses of two samples of tacky rubber by Mr. M. Kelway Bamber :—

Analysis of Black and Yellow Tacky Rubber.

	Black.		Yellow.
	per cent.		per cent.
Moisture ..	.. 0·64	..	0·64
Resin ..	.. 4·00	..	3·02
Proteins ..	.. 2·19	..	2·19
Ash ..	.. 2·02	..	1·26
Caoutchouc	.. 91·15	..	92·89
	<hr/> 100·00		<hr/> 100·00
Nitrogen ..	.. 0·34	..	0·34
Resin by Alcoholic ex- traction	.. 0·68	..	0·72

The first rubber obtained from old trees or that from young trees seems very liable to undergo putrefactive changes. It has been suggested that these decomposition processes may be due to molecular changes of one or more of the constituents of prepared rubber, in which case it would be very difficult to adopt measures to prevent the undesirable result. It has also been pointed out that the presence of large quantities of oily and resinous substances having a low melting point may be the cause of much liquefaction and subsequent decomposition. The chemical analyses of rubber showing varying degrees of tackiness have already been given. They appear to indicate some relationship between the high percentage of resins and proteins and the degree of stickiness and liquefaction. For the sake of comparison the analyses of sound and very tacky rubber are here reproduced :—

	Sound Rubber.		Very tacky Rubber.
	per cent.		per cent.
Moisture ..	.. 0·30	..	0·44
Ash ..	.. 0·38	..	0·72
Resin ..	.. 2·36	..	3·70
Proteins ..	.. 3·50	..	4·90
Rubber ..	... 93·46	..	90·24
	<hr/> 100·00		<hr/> 100·00

The development of bacteria, which has been shown to be associated with putrefactive changes of rubber, might, however, be overcome either by inoculation, effective drying, or the use of antiseptics.

MOULDS ON RUBBER.

An examination of the rubbers from various countries was carried out by Petch, (Annual Report, 1906) in order to determine their comparative resistance to moulds. The mould which grows on prepared rubber in Ceylon is apparently *Eurotium candidum* Speng.



CHAPTER XX.

WHAT TO DO WITH THE SEEDS.

Number of seeds per tree—Seed characteristics—Value—Seed oil and fat—Meal and cake—Analysis of meal—Cake of Para rubber seed compared with linseed and cotton cake—Packing Para seeds for transport—Experiments at Trinidad and Singapore—Charcoal, sawdust, and Wardian cases.—Ridley against Wardian cases.

IT is well-known that trees of *Hevea brasiliensis* flower and fruit after their fifth year in Ceylon. In other countries plants raised from cuttings have been known to produce fruits within three years. Each fruit usually contains three seeds, and the number of seeds annually produced per tree is about five hundred when the trees are mature.

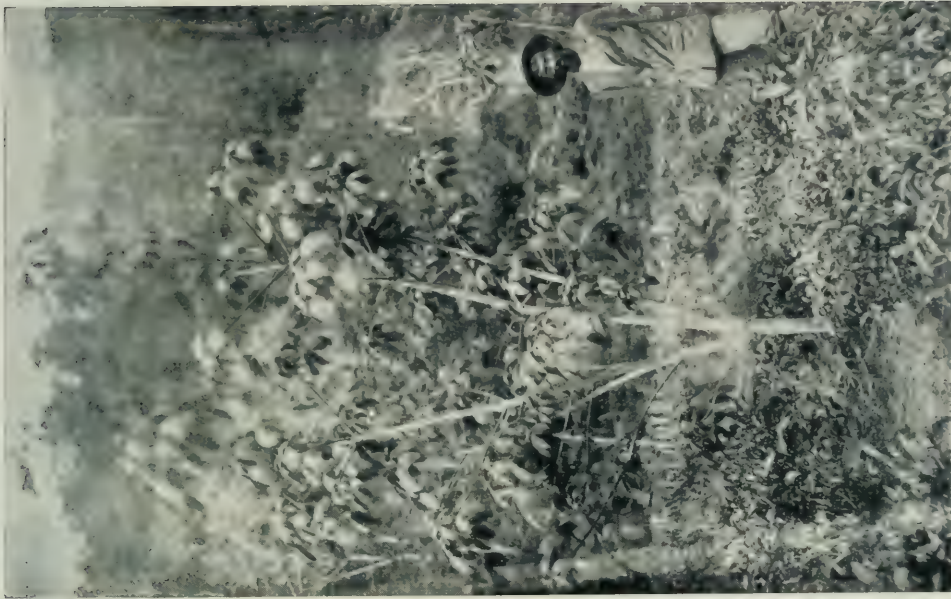
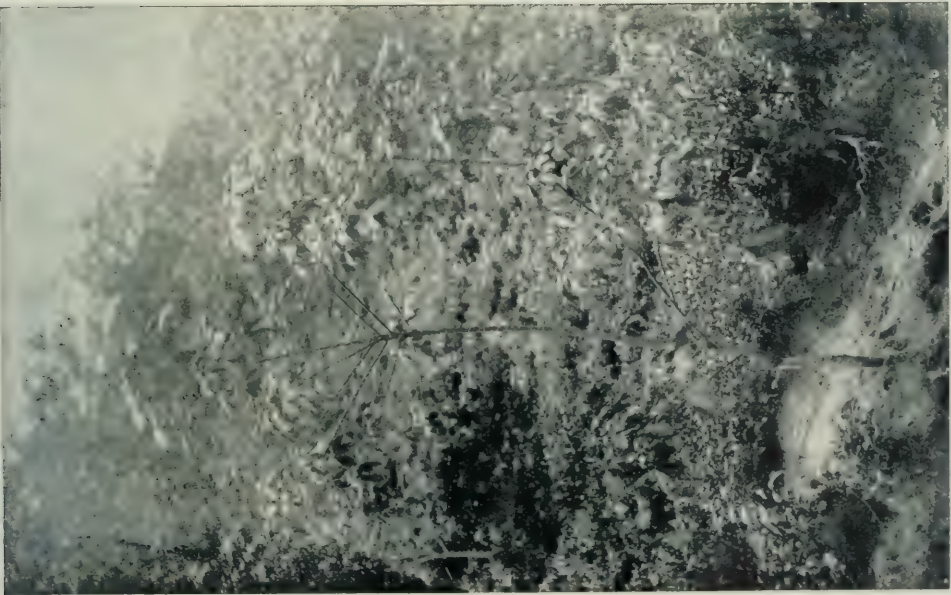
The following interesting information was published in the "Times of Ceylon" regarding the number of seeds produced from a five-year-old tree and its offspring, assuming that each tree after attaining its fifth year produces 500 seeds annually :—

Year.	Total Seeds at end of each year.	Year.	Total Seeds at end of each year
1st	501	11th	130,255,501
2nd	1,001	13th	1,259,006,501
3rd	1,501	15th	4,388,757,501
4th	2,001	17th	323,019,508,501
6th	253,001	18th	952,522,759,001
8th	1,504,001	19th	2,208,151,259,501
10th	3,755,001	20th	4,402,530,010,001

The 500 old trees at Henaratgoda and Peradeniya produce annually about 200,000 seeds, equal to approximately one ton by weight. At the present time there are about 150,000 acres of Para rubber trees in Ceylon, 100,000 acres in Malaya, and very large areas in other parts of the world. It is, therefore, necessary to study the properties of the seeds in the event of more being produced than are required for planting purposes. It is obvious from a glance at the above table that, before long, very large quantities of seeds will be available.

I visited several estates in the East during 1908, where the seed supply was wasted; the price paid for seed for planting purposes did not permit of a profit being made.

The seeds of Para rubber contain an oil which has been valued at £20 per ton, and also yield a cake which may be valued at £5 to



Photos: by G. H. Gollidge.

HEVEA BRASILIENSIS FROM CUTTINGS PLANTED IN 1902.

£6 per ton. The decorticated seeds have been valued at £10 to £12 per ton, and brokers in Europe consider that it would be more profitable to ship the seeds from the Tropics to Europe.*

PARA RUBBER SEED OIL AND FAT.

"The kernels constitute about 50 per cent. by weight of the whole seeds, and yield 42·3 per cent. of oil. The husk and kernel together yield 20 per cent. of oil. The oil is clear, light yellow in colour, and on saponification with caustic soda furnishes a soft soap of yellowish colour. If the seed has been ground to a meal the oil extracted is solid owing to decomposition; but that expressed from the freshly-ground seed is liquid. The husks contain a solid fat in small quantities."*

PARA RUBBER SEED MEAL AND CAKE.

Old ground seed so finely divided as to form a meal was reported upon by the Imperial Institute as follows :—

Chemical Analysis.

	per cent.		per cent
Moisture ..	9·1	Oil	36·1
Ash ..	3·53	Proteins ..	18·2
Fibre ..	3·4	Carbohydrates	29·67

The ash was found to contain 30·3 per cent. of phosphoric acid present in the form of phosphates, which is equivalent to 1·07 per cent. of phosphoric acid in the meal.

The meal thus prepared is unsuited for cattle food on account of the large quantities of free fatty acids and cannot be used for oil extraction. "It is probable, however, that if the oil were expressed from the decorticated seeds, the residual cake could be utilised as a feeding material, as is shown by the following comparison between the calculated composition of such a cake and the compositions of some commerical feeding cakes."

		Calculated Composition of Para rubber seed Cake.	per cent.	Linseed Cake.			Cotton Seed Cake.	per cent
				New Process.	Old Process.	New process.		
Moisture ..	..	13·36	..	9·4	..	10·8	..	11·1
Ash ..	..	5·19	..	5·4	..	5·0	..	6·1
Proteins ..	..	26·81	..	35·6	..	28·6	..	38·47
Fibre ..	..	5·00	..	7·1	..	6·7	..	9·78
Fat ..	..	6·00	..	7·5	..	10·6	..	8·78
Carbohydrates	..	43·64	..	35·0	..	38·3	..	25·75
Nutrient value	.	84·25	..	87·85	..	91·28	..	84·4

* A Report by the Director, Imperial Institute, London.

"These figures show that a cake prepared from Para rubber seed meal may form a good cattle food, and that it contains very little indigestible matter."

There is, therefore, in Para rubber seeds an economic product which may soon become important commercially; if the oil is expressed from the kernels before the meal or cake is made, the residue may be used in the Tropics either as cattle food or manure.

PACKING SEEDS FOR TRANSPORT.

The difficulty of transmitting seeds of *Hevea brasiliensis* to distant countries is well-known; the seeds do not retain their germinating capacity for a very long time except great care is taken in collecting and packing operations.

Twenty seeds were sent from Singapore on February 12 to Mexico, where they arrived on May 2 in the same year; from these fourteen plants were raised.

Seeds of Para rubber, after being dried in the sun for a short time, packed in dry earth, and sent from Penang and Ceylon to India, have arrived in the latter place with only 17 and 31 per cent. of loss due to the seeds going bad. They have also been successfully sent in burnt ricedust or powdered charcoal in hermetically sealed boxes or tins over very long distances. From 30,000 seeds packed with charcoal and sawdust in ordinary cases, sent from Ceylon to the Gold Coast, 3,650 plants have been raised.

Wardian cases have also been used with conspicuous success. Each case is made to hold from 1,500 to 3,000 seeds, the earth and packing material forming alternate layers with the seeds. From 20,000 seeds packed with moist soil in Wardian cases, sent from Ceylon to the Gold Coast, some 3,400 plants were raised.

EXPERIMENTS AT TRINIDAD AND SINGAPORE.

Mr. Hart, Superintendent, Botanic Gardens, Trinidad, assures me that he always keeps Para rubber seeds damp and never dries them, and objects to the use of charcoal in packing, as he believes the latter abstracts the moisture from the seeds. Mr. Hart informs me that coconut dust is best when "tobacco damp," and seeds packed with this material, in small tins of $\frac{1}{2}$ lb. or so, keep sound, germinate freely, and do well when disentangled.

The Director, Botanic Gardens, Singapore, has recently sent quantities of Para seed to Jamaica, Kew, Mexico, &c., with satisfactory results. The seeds were sent to Jamaica in biscuit tins, packed in slightly damped incinerator earth, with the upper part filled with sawdust to reduce the weight; the other seeds were sent in biscuit tins filled with damp finely-powdered charcoal.

"In packing, a certain amount of care is required in damping the charcoal so as to get it equally moistened all through and not either over wet or over dry. This is best done by damping the charcoal

thoroughly and then drying it in the sun, consistently stirring and turning it over till it is uniformly slightly damped. The incinerator earth, which had been exposed to the elements, was damp when received, and only wanted partial drying to fit it for packing. Its weight is against its use, but both it and the powdered charcoal have the great advantage of preventing any attacks of mould or bacteria likely to cause decomposition. Other experiments with powdered coir fibre and coirdust, sawdust, and variously prepared soils have been tried, but the results do not seem to have ever been as successful.”*

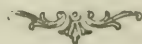
I am obliged to Mr. H. F. Macmillan, Curator of the Royal Botanic Gardens, Peradeniya, for the following notes on the methods of drying and packing seeds of Para rubber:—

“Unless the seeds are sown or despatched almost as soon as collected they should be spread on a dry cool floor, and turned over frequently to prevent heating. It is often unavoidably necessary to keep the seeds on hand for several days, and an important question is the condition under which they may be stored to preserve their vitality best. When a large amount has to be dealt with a quantity of broken-up charcoal should be in readiness for mixing with these, or, if this be not available, dry sand may with advantage be used instead. On no account should the seeds be covered or surrounded with any damp material; nor should they, on the other hand, be unduly exposed to sun heat. Small quantities of Hevea seeds may be packed with coconut dust in biscuit or tobacco tins and sent long journeys by post. On short journeys not exceeding six or seven days they may be sent by post, without any packing, in small gunny bags holding 500 and weighing about 6 pounds. Obviously, however, this would not be practicable for a large quantity, even if the postage were not prohibitive. For journeys of about a fortnight to three weeks ordinary strong cases, about 30" × 16" × 12", and holding when packed 6,000 to 7,000 seeds may be used. A thin layer of dry charcoal mixture is placed in the bottom of the case, then a covering of paper (to prevent the compost filtering to one side in transit), next a layer of seed followed by mixture, and so on. One part charcoal to two of coconut dust or sawdust is very satisfactory. This has also the merit of being light in weight, which is a consideration in transport charges. It must be remembered, however, that the success of this method depends upon the freshness of the seed as well as on the length of journey. The method of packing the seed in sealed kerosine oil tins has been tried, but with indifferent results. Treating the seed with a 4 per cent. solution of copper sulphate or formalin may have the effect of preventing the growth of mould on the seeds and thus prolonging their vitality, but its application is unnecessary, except perhaps in extreme cases. By far the most satisfactory means of transporting Hevea seeds is by way of Wardian cases.”

WARDIAN CASES.

The principle of the foregoing methods, it will be seen, is to retard the effort of the seed to germinate and remove conditions which induce germination; that of the Wardian case is to encourage germination; for the seeds being sown, not "packed," are at once encouraged to germinate and grow into plants. The initial cost in this instance is greater, but the saving in the long run is evident. If good seeds are sown they will germinate in about ten or twelve days, and the percentage of failures would be nil; the seedlings may then be tended in the cases as if they were in a nursery bed, and an opportunity of shipping may be awaited without risk or anxiety. Thus on arrival at destination instead of receiving seed with a doubtful percentage of germinating power you should have good-sized plants or "stumps." The principle of the Wardian case consists of filling the body of the latter to a depth of five inches with a light porous compost (say two parts leaf-mould to one of decayed coconut dust, with a sprinkling of charcoal); upon this is placed a layer of about 1,500 seeds (or if necessary two layers of 1,000 each with compost between), finishing with a covering of about an inch of compost. The whole is then thoroughly watered, after which small bamboo twigs are placed thinly and longitudinally on top; across these are placed narrow battens three inches apart, these being kept in place by a longitudinal strip nailed along both insides of the case. The latter is then raised on four bricks to allow the escape of water as well as to prevent attack by white ants. The contents must be kept moist by watering them each day if the weather be dry. It is best to allow the seeds to germinate before despatching. The two glazed top sides are left off to the last. These when screwed on admit the necessary light, whilst fresh air is provided by a ventilator in each end covered with fine gauze with a box nailed on to the inside for preventing sea spray reaching the plants. The advantage of thus having plants instead of seeds at destination, which may mean a year gained in planting, only costs about Rs. 5 per thousand more than the price actually paid for seeds that have been packed and despatched in the dry method—that is allowing for 50 per cent. of these to germinate and the cost of the Wardian case to be Rs. 15.

Ridley maintains that the Wardian cases are expensive and unsatisfactory and considers that the method adopted in Singapore of packing in slightly damped charcoal or burnt rice dust has given better results. He is strongly against using cocount dust and saw dust.



CHAPTER XXI.

ESTIMATES OF RUBBER PLANTERS:

COSTS OF PLANTING RUBBER IN CEYLON, MALAYA, JAVA, SOUTH INDIA, AND BORNEO.

Estimate I. by E. Gordon Reeves. Rs. 322.40 per acre at end of 5th year for Matala—Estimate II. by F. J. Holloway, Rs. 283.50 per acre at end of 6th year.—Estimate III., Peradeniya District for first two years—Estimate IV., Kalutara District for first six years—Estimate V., Ambalangoda District for first two years—Estimate VI., Ambalangoda District for first two years in swampy land—Estimate VII., Ambalangoda District for first two years.—Estimate of cost of developing 500 acres under Para rubber in Malay Peninsula, upkeep of same and returns up to the eighth year by Stanley Arden—Cost of planting 1000 acres and profits therefrom in Malaya, by Carruthers—Growth on Seafield Estates—Cost of planting rubber and profits therefrom in Java, by Noel Bingley and A. H. Berkhout—Estimate of cost of 300 acres of Para rubber in South India, by E. G. Windle.—Cost of planting Para rubber in Borneo.

THE cost of clearing, draining, and planting up large acreages of Para rubber necessarily varies according to the condition of the forests to be cleared, the nature of the land, and the rates of wages paid, &c. The following estimates have been kindly supplied to me by friends in Ceylon. (Rupee = 1s. 4d.) :—

ESTIMATE I.

ESTIMATE OF COST OF PURCHASING 100 ACRES OF LAND AND PLANTING WITH PARA RUBBER.

Cost of 100 acres of Land—	Rs.	c.	Rs.
Forest say @ Rs. 60 per acre } say	50	0	per acre .. 5,000
Chena ,, 40 to Rs. 45 }			

CLEARING—

100 acres Forest @ Rs. 20 per acre } say	17	50	per acre .. 1,750
100 acres Chena @ Rs 15 to Rs. 17 }			

NURSERIES AND SEEDS—40,000 seeds at

Rs. 7 per 1,000 ..	280	0
30,000 Baskets, Rs. 4 per 1,000 ..	120	0
Making nurseries, including sheds for basket plants, sowing seed ..	60	0
Upkeep, watering for 3 months regularly	30	0
Further occasional attendance for six months	20	0

ROADS AND DRAINS—at Rs. 6 per acre	..	.. 510
		.. 600

LINING—say 15' by 15'—about 200 trees per acre, including cost of pegs, @ 75 cents per acre 75
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Carried forward		7,935
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PARA RUBBER

			Rs.
	Brought forward ..		7,935
HOLING—Holes 18" by 12": task 40 per man, say Rs. 1.80 per acre			180
PLANTING—20,000 Basket plants including transport from nurseries: dipping in liquid manure, &c., 80 cents per acre			80
SUPPLYING—Putting out 6,000 basket plants @ 50 cents per 100			30
SHADING—30,000 cadjans @ Rs. 10 per 1,000 ..	Rs. 300		
Making up: fixing and general attendance, say Re. 1.50 per acre		150	450
LINES—1 set of temporary lines, 20 rooms: jungle post thatched roof; mud and wattle walls; @ Rs. 20 per room			400
WEEDING—Forest land: first 3 months } say 10 months' weeding at Re. 1.25; thereafter @ 80 } of 1st year at Re. 1.50 cents } per acre ..			1,50
Chena Land: ..			
First 3 months @ Rs. 2.50 {			
Second 3 months .. 1.75 {			
Thereafter .. 1.0 {			
FENCING.—Cost of wire and staples } about Rs. 150 per mile, } 3 wires at 1 foot apart } Rs. 187 per mile allowed— Posts: cutting holes, &c., } per 3 miles ..			561
and fixing, Rs. 30 per mile } Carpenters at Rs. 7 per mile }			
TOOLS, say Rs. 100 {			200
CONTINGENCIES, Rs. 100 {			
SUPERINTENDENCE at Rs. 100 per month			1,200
COAST ADVANCES; 80 coolies say Rs. 30			2,400
		Rs.	14,936
Brought forward, first year's expenditure			14,936
Add interest at 7% say			1,045
		Rs.	15,981
2nd Year ..			
Superintendence say ..	1,000		
Weeding 100 acres at Re. 1 ..	1,200		
Nurseries, supplying cadjans, &c., ..	105		
Roads and drains upkeep ..	50		
Thatching lines Re. 1.50 per room ..	30		
Upkeep of fence ..	50		
Contingencies ..	100		
			2,535
Add interest on Rs. 18,511 at 7%			1,290
Carried forward ..			19,806

PARA RUBBER.

279

				Rs
		Brought forward	..	19,806
				Rs
3rd Year	Superintendence	...	900	
	Weeding at 80 cents	...	800	
	Supplying and nurseries	...	100	
	Roads and drains	...	50	
	Lines	..	30	
	Fencing	..	30	
	Contingencies	..	100	
				2,010
	Add interest on Rs. 21,816 at 7%	..	..	1,527
				Rs. 23,343
4th year	Superintendence	...	720	
	Weeding at 75 cents	...	750	
	Supplying, &c.	..	100	
	Lines: 20 rooms—permanent stone pillars, mud and wattle walls, iron roof, Rs. 70 per room	..	1,400	
	Fencing	..	30	
	Contingencies	..	70	
				3,070
	Interest at 7% .. ..	..	..	1,848
				Rs. 28,261
5th Year	Superintendence	..	900	
	Weeding	..	750	
	Fencing	..	50	
	Contingencies	..	70	
	Roads &c., and general attention	..	100	
				1,870
	Interest at 7 %	..	..	2,109
				Rs. 32,240

Rs. 322.40 per acre at end of fifth year.

MEMOS.—I close the estimate at termination of the fifth year as it is now generally admitted that tapping may commence according to growth between the end of fourth and sixth years.

The estimate is framed on the lines of Rubber planting as ordinarily carried on in the district of Matale, and might serve as a guide to the planting of Rubber in such districts as Badulla Valley, Kurunegala, Dumbura, &c., districts usually not heavily influenced by the rains of the south-west monsoon.

FELLING.—The cost of felling and clearing both of forest and chena land is so very variable, that it is impossible to give an estimate which would apply to the Rubber districts generally.

CLEARING.—In some districts I have had chena lands cleared for Rs. 9 per acre; and, again, the felling of forest will not be taken up by contractors in some localities for less than Rs. 25 per acre.

ROADS AND DRAINS.—The cost would be from Rs. 5 to Rs. 8 per acre according to lay of land, soil, &c

FENCING.—Fencing can only be estimated for by the mile. Many estates or clearings, covering perhaps only 100 to 150 acres, would require 3 to 4 miles of fencing owing to established rights of way. My estimate is for a treble wire fence.

It is not at all certain that it would not pay in cases where clearings have a jungle frontage to put up 2 wires only say at 1 foot 6 inches and 3 feet, backed by galvanized wire 3 feet by 3 inches mesh.

The cost of the barbed wire fence would be reduced to Rs. 50 per mile. The galvanized wire would cost about Rs. 285 per mile. The total cost of such fencing would therefore work out at about Rs. 422 per mile.

It would effectually put as top to the depredations of muntjak deer, mouse deer, porcupines, and hares, and those who have clearings along a jungle edge know what damage such animals can do.

PLANTING.—The use of basket plants and shading with cadjans adds about Rs. 5 to Rs. 6 per acre to the cost of planting; but results prove that this extra expense is well repaid

WEEDING.—This is an item which may very easily exceed the estimate I have given as regards chena lands. The first year's weeding should not, however, in any case cost over Rs. 3 per acre per month—say Rs. 36 per acre for the year for the weediest chena lands. It may cost this unless labour is very plentiful. From fourth year the weeding should be reduced in either forest or chena land clearings to an average of 75 cents per acre.

SUPERINTENDENCE.—Has been estimated for on the supposition that the clearing is being looked after by the manager of an adjoining property. In the case of an estate of considerable acreage being concerned this item would be chargeable at Rs. 10 per acre per annum all through.

BUILDINGS.—I make no estimate for Factory, Superintendent's Bungalow, &c., though both would be required. Superintendent's bungalow could be built for about Rs. 2,000.

It is useless at the present stage of the industry to make an estimate for a Factory, as the invention of suitable machinery, which is sure to follow during the next year or two, will revolutionise the curing of Rubber. It would probably be safe, however, to allow at the rate of Rs. 50 per acre as the cost of the building only.

COAST ADVANCES.—I have charged as an ordinary item of expenditure. It is only fair to do so, as it is an item which, though slightly varying in amount, is never absent, and is just as really a charge on the estate as Superintendence or any other item and should be recognised as such. The amount Rs. 2,400 would probably be exceeded from and after the sixth year on tapping operations commencing.

E. GORDON REEVES.

Wiltshire,

Matale, October 10, 1905.

ESTIMATE II.

PARA RUBBER IN CENTRAL PROVINCE.

ESTIMATE FOR OPENING LAND AND NOTES ON SAME.

In making an estimate for opening land there are many things to be taken into consideration, such as (1) the nature of the jungle to be felled—whether high or low; (2) nature of soil—whether good soil with rocks or hard gravelly soil; (3) lay of land—if the land is fairly flat with few rocks or stones the work will be much cheaper than on a rocky and hilly estate; (4) local conditions of labour—in some districts the cooly is paid 33 cents per day, in others 50 cents.

Therefore, I should not think of framing an estimate until I saw and examined the land. The whole work with the exception of felling and clearing can be done cheaper with Tamil than village labour.

The cost of felling and clearing varies from Rs. 12.50 to Rs. 20; roads and drains according to lay of land Rs. 7.50 to Rs. 12, and even Rs. 20 per acre in rocky and hilly land, as blasting and building is an expensive item.

Barbed wire and fencing is an important item, and I have added this to the estimate.

I have slightly revised my estimate as published in the *India-Rubber Journal* of May and June, 1904, and have now brought it up-to-date, having benefited by the experience in opening 869 acres during the past twelve months.

The following estimate is made for an estate in the Central Province worked entirely by village labour. Lay of land, mostly on hillsides, with a fair number of rocks—average cost of labour about 40 cents per day. I strongly advocate seed at stake in all new clearings.

ESTIMATE OF PURCHASING AND OPENING 300 ACRES OF LAND.

1.—Purchase of land, say 300 acres, at Rs. 50 per acre ..	Rs.15,000
2.—Felling, burning, clearing, rooting 300 acres, at Rs. 15 per acre	4,500
3.—Roads and drains, blasting and building, at Rs 12 per acre ..	3,600
4.—Lining and pegs, 15 by 15, at Re. 1.50 per acre ..	450
5.—Holing 2 ft. by 15 in. and filling, at Rs. 6.50 per acre ..	1,950
6.—Cost of seed at Rs. 6 per 1,000, 3 in a hole, at 5 cents per acre, and planting	1,500
7.—Nursery basket plants for supplies, 6,000 and upkeep ..	150
8.—Planting, 1.50 per acre	450
9.—Weeding, April to December, at Rs. 20 per acre ..	6,000
10.—Bungalow Rs. 2,500, lines (20 rooms) Rs. 600 ..	3,100
11.—Superintendent Rs. 3,000, Conductor Rs. 600 ..	3,600
12.—Tools and contingencies	750
13.—Barbed wire fence, 4 strands put 8 ft. apart, and erection of same, at 15 cents per yard, or, in round figures, say, at Rs. 5 per acre	1,500
(If 2-in. wire netting buried and put in ground—and 3 strands of barbed wire and erection, at Rs. 9 per acre.) ..	42,550
2nd to 6th year supervision, Rs. 3,600 ..	18,000
Weeding second year at Rs. 20 per year, Rs. 6,000 ..	19,500
„ third year at Rs. 15 per year, Rs. 4,500 ..	
„ fourth to sixth year at Rs. 10 per year, Rs. 9,000 ..	
Upkeep of roads and drains at Re. 1 per acre, 5 years at Rs. 5 ..	1,500
Carried forward ..	81,550

PARA RUBBER.

	Rs.
Brought forward ..	81,551
Upkeep of lines and bungalow, &c., 5 years ..	1,250
Supplying and attending young plants, 5 years at Rs. 200 ..	1,000
Sundries and contingencies, 5 years at Rs. 250 ..	1,250
Total cost of 300 acres, at 1s. 4d.=£5,670 or £18 18s. per acre.	Rs. 85,050

October 14, 1905.

FRANCIS J. HOLLOWAY.

ESTIMATE III.

FIRST AND SECOND YEARS—PERADENIYA DISTRICT.

	First Year.	Second Year
	Rs. 10 0	Rs. 10 0
Superintendence ..	Rs. 10 0	Rs. 10 0
Felling	12 0	—
Lining, 18 feet by 18 feet ..	1 0	—
Pegging	1 0	—
Roads and drains ..	15 0	1 50
Fencing with barbed wire ..	14 0	—
Holing	6 0	—
Filling and planting ..	3 0	—
Plants	1 50	0 50
Weeding	10 0	9 0
Buildings	8 0	0 25
Tools	0 50	—
Contingencies ..	2 0	—
Supplying and fencing ..	—	2 0
	84 0	23 25

ESTIMATE IV.

FIRST TO SIXTH YEAR—KALUTARA DISTRICT.

The following estimate of the cost of opening up Para rubber land is about the average for light low-country jungle land in the Kalutara District. On many estates the cost for the first six years works out at from Rs. 180 to Rs. 200 per acre.

	1st year,	2nd year,	3rd year,	4th year,	5th year,	6th year.
	Rs. c.	Rs. c.	Rs. c.	Rs. c.	Rs. c.	Rs. c.
Felling and clearing	8 0	—	—	—	—	—
Drains	12 0	—	—	—	—	—
Roads	4 0	2 0	1 50	1 50	1 0	1 0
Holing and filling ..	5 0	—	—	—	—	—
Lining and pegs ..	2 0	—	—	—	—	—
Weeding	18 0	16 0	12 0	12 0	12 0	12 0
Fencing	4 0	2 0	2 0	1 0	1 0	1 0
Plants	4 0	—	—	—	—	—
Planting	1 0	2 0	—	—	—	—
Tools	2 0	0 50	0 50	—	—	—
Superintendence ..	12 0	5 0	5 0	5 0	5 0	5 0
Survey, &c., and contingencies ..	1 0	0 50	0 50	1 0	1 0	1 0
	73 0	28 0	21 50	20 50	20 0	20 0

Total—Rs. 183.

ESTIMATE V.

FIRST AND SECOND YEARS—AMBALANGODA DISTRICT.—COST PER ACRE.

		First Year.	Second Year
		Rs. c.	Rs. c.
Felling and clearing	.. ..	10 0	—
Lining and pegging	.. ..	2 0	—
Roads and drains	.. ..	15 0	1 50
Fencing with barbed wire	.. ..	5 0	—
Holing	.. ..	9 0	—
Filling and planting	.. ..	7 0	—
Plants	.. ..	1 50	0 50
Weeding	.. ..	12 0	12 0
Contingencies	.. ..	2 0	1 0
Supplying and fencing	.. ..	—	1 50

ESTIMATE VI.

FIRST AND SECOND YEAR—AMBALANGODA DISTRICT.

Principal Items in opening Swampy Land.

		First Year.	Second Year
		Rs. c.	Rs. c.
Felling and clearing	.. ..	4 0	—
Lining and pegging	.. ..	2 0	—
Roads and drains	.. ..	30 0	10 0
Heaping soil	.. ..	8 50	—
Fencing with wire	.. ..	5 0	—
Filling and planting	.. ..	7 0	—
Weeding	.. ..	24 0	24 0
Contingencies	.. ..	2 0	1 0
Supplying, &c.	.. ..	—	1 50

ESTIMATE VII.

ESTIMATE OF OPENING ONE ACRE UNDER RUBBER IN LOW-COUNTRY,
AMBALANGODA.

			Rs. c.
Superintendence	.. ..	..	10 0
Cost of watering and rearing plants, per 1,000	.. ..	..	2 0
Felling and clearing	.. ..	..	8 0
Lining, 20 by 20	.. ..	..	1 50
Holing and filling in, 2 by 2 by 2	.. ..	..	9 0
Planting	.. ..	..	1 0
Wear and tear of tools	.. ..	..	2 50
Weeding, per month, Re. 1.50	.. ..	..	18 0
Drains	.. ..	..	8 0
Roads	.. ..	..	5 0
Supplying	.. ..	..	0 50
Fencing with barbed wire	.. ..	..	3 0
			68 50

No bungalow or lines estimated for in either first or second year. Cost of plants or watchman not taken into consideration, the cost of former being too fluctuating.

SECOND YEAR.				Rs.
Superintendence	..	..	..	5 0
Weeding, per acre per month, Re. 1	..	..	..	12 0
Supplying	..	..	..	1 0
General upkeep—drains, roads, and contingencies	..	..	..	5 0
				<hr/>
				23 0

In the foregoing estimates I have given the figures as presented to me by my friends. Items such as Superintendence and Interest are not always shown, and the variation in cost of felling, clearing, and weeding is very great.

**ESTIMATE OF COST OF DEVELOPING 500 ACRES UNDER PARA RUBBER
IN MALAY PENINSULA AND UPKEEP OF SAME (WITH RETURNS)
UNTIL THE EIGHTH YEAR,**

BY STANLEY ARDEN.				£
COST OF LAND--				
* Premium on 500 acres at \$3 per acre	...	...	...	1,500
Quit rent first year \$1 per acre	...	...	...	500
Survey fees, Registration, etc.	...	...	...	150
FIELD WORKS--				
Felling jungle—250 acres at \$9 per acre	...	...	...	2,250
Burning off and Clearing up 250 acres at \$5 per acre	...	...	...	1,250
Draining and Inspection Paths 250 \$12 .. ..	...	...	...	3,000
Lining (including cost of pegs) \$1.50 .. ..	...	...	...	375
Holing - 150 per acre—and filling with surface soil \$2 per acre	...	...	...	500
Planting with Stumps from Nurseries \$1 per acre	...	...	...	250
Supplying, 50 cts. per acre	...	...	...	125
Nurseries, preparation of Seed Beds, Sowing, etc.	...	...	...	250
Seeds, 100,000 at \$6 per 1,000	...	...	...	600
Weeding 100 acres 9 months \$1 per mensem )	...	...	...	1,800
150 .. 6 .. \$1 .. .. }	...	...	...
BUILDINGS--				
Superintendent's Bungalow	...	...	...	1,000
Barrack furniture for same	...	...	...	250
Bungalows for Apothecary and Conductor	...	...	...	500
Cooly Lines to accommodate 200 coolies. 50 rooms at \$30 per room	...	...	...	1,500
† Hospital	...	...	...	500
Sundry Buildings—Rice Store, Tool Store, etc.	...	...	...	250
UPERVISION--				
Superintendent's salary \$300 per mensem	...	...	...	3,600
Apothecary's .. \$75 .. ..	...	...	...	900
Conductors .. \$50 .. ..	...	...	...	600
MISCELLANEOUS--				
Tools and Implements	...	...	...	500
Immigration expenses, loss on Coast Advances, etc.	...	...	...	1,000
General Transport	...	...	...	250
Contingent expenses, Medicines, Postages, etc.	...	...	...	1,000

* After the sixth year the quit rent is \$4 per acre.

† The cost of erection of a hospital and salary of a qualified Apothecary are included, as by a recent enactment Government now requires each estate to erect a Hospital.

ESTIMATE OF COST IN MALAY PENINSULA--*Contd*

2nd year	...	Cost of opening 250 acres as above	...	\$21,100
		Less premium	...	\$1,500
		.. Survey Fees	...	150
		.. Buildings	...	4,000
				<hr/> 5,650
				18,750
		Upkeep of first 250 acres at \$30 per acre	...	7,500
3rd year	...	.. 500 acres at \$30 ..	...	15,000
4th year	...	Do	...	15,000
5th year	...	Do	...	15,000
		Total Expenditure to end of 5th year...		95,650
6th year	...	Upkeep of 500 acres at \$30 per acre	...	15,000
		Extra cooly accommodation	...	500
		Manager's bungalow	...	2,500
		Curing and Drying Store, Machinery, etc., (say)	...	10,000
		Immigration expenses, loss on Coast Advances, etc.	...	2,500
		Tapping and Collecting (including cost of knives and cups) Curing, Packing, Freight* Export Duty, etc.	...	12,500
		25,000 lbs. Rubber at 50 cts. per lb.	...	12,500
		Total expenditure to end of sixth year	...	138,600
7th year	...	Upkeep 500 acres at \$30 per acre	...	15,000
		Collecting, Curing and Marketing 75,000 lbs. rubber at 50 cts.	...	37,500
		Total expenditure to end of seventh year...		191,150
8th year	...	Upkeep 500 acres at \$22 per acre	...	12,500
		Collecting and Marketing 112,500 lbs. rubber at 40 cts.	...	45,000
		Total expenditure to end of 8th year	...	\$248,650
		Exchange 2/4 = \$1	...	\$29,253

ESTIMATE OF RETURNS FROM RUBBER.

6th year	...	250 acres (375,000 trees) at $\frac{3}{4}$ lb. per tree, say	£	s.	d.
		100 lbs. dry rubber per acre = 25,000 lbs.			
		at 3s. per lb.	...	3,750	0 0
7th year	...	250 acres as above = 25,000 lbs.	£3,750		
		250 .. at $1\frac{1}{4}$ lbs. per tree, say 200 lbs.			
		per acre = 50,000 lbs. dry rubber at			
		3/- per lb.	...	7,500	
				11,250	0 0
8th year	...	250 acres as above 200 lbs. per acre	...	7,500	
		260 .. at 250 lbs. per acre = 62,500 lbs.			
		dry rubber at 3s. per lb.	...	9,375	
				16,875	0
				£31,875	0 0

The present price of "Plantation Para" is 5s. 3d. per lb., but for the purposes of this estimate I have taken it at 3s. per lb. It will be seen that I anticipate that the whole of the capital expended on development will be repaid by the end of the eighth year; the yield during the ninth year should average 300-350 lbs. per acre which, on a selling basis of 3s. per lb. less 1s. per lb. for harvesting and marketing, will realise a net profit of £30-£35 per acre, which will again be considerably increased during the tenth year. The cost of upkeep at this stage should not exceed £3 per acre.

JOHORE, 1st October, 1907.

STANLEY ARDEN.

* There is an export duty of 2½% ad valorem

MALAYA.

COST OF PLANTING AND PROFITS.

ESTIMATES FOR 1,000 ACRE ESTATE, 250 ACRES TO BE OPENED EACH
YEAR. F.M.S.

(By favour of J. B. Carruthers, Director of Agriculture, F.M.S.)

FIRST YEAR.

	\$		£
Premium	3,000	Lines	1,500
Survey Fees	1,000	Medical, Hospital Medicines, &c.	2,000
Rent	1,000	Labour Advances, Immigration Fees, &c.	1,500
Clearing, Felling and Burning 250 acres (\$15 per acre)	3,750	Superintendence	3,600
Lining, Holing and Planting 250 acres (\$6 per acre)	1,500	Tools and Sundries	1,000
Plants	800		
Roads and Drains (\$6 per acre)	1,500		£24,150
Bungalow	2,000		

SECOND YEAR.

	\$		£
Rent	1,000	Superintendence	4,000
Clearing, Felling and Burning 250 acres	3,750	Tools and Sundries	750
Lining, Holing and Planting 250 acres	1,500	Weeding 250 acres	2,500
Plants	800	Supplying	100
Roads and Drains	1,500		£17,900
Medical	1,000		
Labour	1,000		

THIRD YEAR.

	\$		£
Rent	1,000	Labour	1,000
Clearing, Felling and Burning 250 acres	3,750	Superintendence	4,000
Lining, Holing and Planting 250 acres	1,500	Tools and Sundries	1,000
Plants	800	Weeding 500 acres	6,000
Lines	1,500	Supplying	100
Roads and Drains	1,500		£23,150
Medical	1,000		

FOURTH YEAR.

	\$		£
Rent	1,000	Labour	1,000
Clearing, Felling and Burning 250 acres	3,750	Superintendence	4,000
Lining, Holing and Planting 250 acres	1,500	Tools and Sundries	1,000
Plants	800	Weeding 750 acres	12,000
Roads and Drains	1,500	Supplying	100
Medical	1,000		£27,650

PARA RUBBER.

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MALAYA- *Contd.*

FIFTH YEAR.

	\$		\$
Rent ...	1,000	Tools and Sundries	1,000
Roads and Drains	800	Weeding 1,000 acres	15,000
Medical	1,000		
Labour	1,000		\$23,800
Superintendence	4,000		

SIXTH YEAR.

	\$		\$
Rent ...	1,000	Tools and Sundries	1,000
Roads and Drains	800	Weeding 1,000 acres	17,000
Labour	1,000		
Medical	1,000		\$25,800
Superintendence	4,000		

SEVENTH YEAR.

	\$	Weeding 1,000 acres	\$17,000
Rent ...	4,000		
Roads and Drains	800		\$28,800
Medical	1,000		
Labour	1,000	8th and following years as	
Superintendence	4,000	7th Year	\$28,800
Tools and Sundries	1,000	Except that the item for weeding will rapidly decrease till the 13th or 14th year it will be less than	\$1,000

PROFITS.

SEVENTH YEAR.

	\$
250 acres planted 150 trees per acre at 1 lb. rubber per tree sold at 3s. per lb.	48,214
250 acres planted 150 trees per acre at 1½ lb. rubber per tree	72,321
	\$120,535
Less cost of production, shipping, etc., of 93,750 lbs. at 1s. 6d. per lb.	60,268
Nett profit	\$60,267

EIGHTH YEAR.

250 acres at 1 lb. and 3s. per lb.	48,214
" " 1½ " 3s. "	72,321
" " 1 " 3s. "	96,428
	\$216,963
Less cost of production 253,125 lbs. at 1s. 6d.	108,482
	\$108,481

PARA RUBBER.

MALAYA—*Contd.*

PROFITS.

NINTH YEAR.

250 acres at 1 lb. and 3s. per lb.	...	...	48,214
250 „ „ 1½ „ 3s. „	...	...	72,321
500 „ „ 2 lbs. per tree and 3s. per lb.	...	...	192,856
			<hr/>
Cost of production, &c., 243,750 lbs. at 1s. 6d.	...	...	\$313,391
			<hr/>
			156,696
			<hr/>
			\$156,695

TENTH YEAR

250 acres at 1½ lbs. per tree at 3s. per lb	...	...	\$72,320
750 „ at 2 lbs. per tree at 3s. „	...	...	289,280
			<hr/>
			\$361,600
Less cost of production at 1s. 6d. per lb. on 262,500 lbs.	...	...	180,800
			<hr/>
Nett profit...			\$180,800

ELEVENTH YEAR.

1,000 acres at 2 lbs. per tree and 3s. per lb	...	...	\$385,710
Cost of production &c., of 300,000 lbs. at 1s. 6d. per lb-	...	...	192,857
			<hr/>
Nett profit...			\$192,853

and so on each year annual profit \$192,853 with a probability of still increased yield.

ABSTRACT OF ESTIMATES.

Year.	Expenses.	Total.	Profits.	Total Profits.	Nett Profits.
1	24,150	24,150	—	—	—
2	17,900	42,050	—	—	—
3	23,150	65,200	—	—	—
4	27,650	82,850	—	—	—
5	23,800	115,650	—	—	—
6	25,800	142,450	—	—	—
7	28,800	166,250	60,267	60,267	—
8	28,800	195,050	108,481	168,748	—
9	28,800	223,850	156,695	225,444	1,594
10	28,800	252,650	180,800	406,244	153,594
11	28,800	281,450	192,853	599,097	317,647
12	28,800	310,250	192,853	791,950	481,700
13	28,800	339,050	192,853	894,803	645,743
14	28,800	367,850	192,853	1,177,656	809,806

If 5% interest is added each year for interest on the capital expended the money total capital expended is not repaid till the 10th year.

PARA RUBBER.

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GROWTH IN MALAYA.

The estimate of yield is intimately connected with the time taken for the trees to attain a tappable size, and the following statement issued in March, 1908, by the Directors of the Seafield Rubber Company is of interest:—

Planted.	Acre- age.	GIRTHS.				
		Under 9 in.	9 in. to 12 in.	12 in. to 15 in.	15 in. to 18 in.	18 in. & over.
1904 ...	238½	9,850	14,127	17,169	5,576	978
1905 (April—June) ...	159	23,098	5,697	4,197	253	—
1905 (Nov.—Dec.) ...	272	44,877	5,731	2,307	—	—
1906 ...	556½	78,885	—	—	—	—
1907 ...	302	38,772	—	—	—	—

These measurements show the sizes of trees on December 31st, 1907.

JAVA RUBBER PLANTING.

By NOEL BINGLEY.

HEAD OF EXPENDITURE,	A.			B.			C.			D.		
GENERAL EXPENDITURE including :—												
Salaries, Tools, Stable.												
Contingencies, Post and Telegrams,	£.	s.	d.	£.	s.	d.	£.	s.	d.	£.	s.	d.
Etc., Etc.	2	1	6	1	15	4	16	5	16	1	
INVENTORY :—												
(Road Tracer, Safe, etc.)	...		1	3			8		2		4	
BUILDINGS :—												
Bungalows and Lines,	...		7	7		7	5		4	7	5	10
NEW RUBBER CLEARINGS :—												
Stumps	...							1	17	6	1	17
Seed	11	4		15	10						
Nurseries	...		3	6		4	3					
Felling, Clearing and Burning	..	1	0	5	1	3	9	1	0	2	1	9
Digging and Forking	...		9	7		3	0		11	1	3	9
Roads and Drains	13	4		10	6		6	11		1	4
Lining and Holing		4	1		5	8		10	1	6	11
Planting		2	6		2	7		3	1		2
Supplying and Handling	...			6								
Weeding	...	19	4		6	3		13	4		15	8
Barbed Wire Fence	..		6	6		3	10		7	7		6
Pests and Extras	...			5			2		11			—
RUBBER CULTIVATION :—												
Up-keep Roads and Drains	...		5	11		6	9		—			—
Weeding (including uprooting tree Stumps)	...	1	11		5	1	12	0	—			—
Digging and Forking	..		18	11		4	10		—			—
Supplying	..		1	4			2		—			—
Pests, Extras, Topping, etc.	..		1	2			—		—			—
	£.	10	0	7	8	3	0	6	11	10	6	4

(4) Is an Estate where work has been in progress for 28 months—Bouws 927 acres being planted Hevea. 441 Acres were planted 1905-6, 262 in 1906-7 and 224 in 1907-8 planting seasons. The cost of General Expenditure is for the whole period, and calculated over the whole 927 acres. The planting season in Java extends generally from November to end February.

This Estate is mostly flat with a few undulating hills and requires deep draining.

(Continued over.)

JAVA RUBBER PLANTING.—*Contd.*

(A) has a considerable acreage under Catch Crops, but all general Expenditure has been charged to Rubber in above table.

(B) Is an Estate where work has been in progress 20 months—540 Bouws—945 acres—are planted with Hevea of which 175 acres in 1905-6, 287 1906-7 and 483 in 1907-8 seasons.

Cost per Acre under General Expenditure, calculated on same basis as in the case of Estate "A".

This Estate is of a still more flat alluvial nature corresponding closely to the lie of land on Lowlands and Highlands Estate in the Klang District of the F. M. S. and requiring the same system of deep draining.

(C) Is an Estate of a more hilly character, with little heavy forest on it (which accounts for the cheaper cost of felling and burning) upon which 850 Bouws, 1487 acres, have been cleared and planted in 10 months.

(D) Is of a similar lie of land to "C" but was partly heavy Forest and partly second growth and waste land. Here 770 Bouws-1347 acres—have been cleared and planted.

In the case of the two last Estates there has been no opportunity of laying down nurseries before the first year's Clearing, so that stumps had to be bought costing respectively on Estates about 2½d & 2½d each or £. 1. 17. 6. against the 15s to £. 1 per acre seed and nurseries would have cost.

On the other hand as will be seen from above table the character of the land afforded a considerable saving under "Drains" compared with "A" & "B".

Omitting the Expenditure under Rubber Cultivation on upkeep of the older Rubber during 1907 in the case of the two older Estates "A" & "B", the above figures of the four Estates shew an average cost of £. 6. 11. 11. per acre for opening up and Planting an Estate in West Java, inclusive of management, buildings, and all general expenditure extending over 2½ years in the case of "A" & "B".

**ESTIMATE FOR 1,000 BOUWS RUBBER IN THE PREANGER
RESIDENCY OF JAVA.**

(PLANTING DISTANCE, 20 × 10.)

(One bouw equals 1½ acres; One guilder equals 1s. 8d.)

FIRST YEAR.

GENERAL EXPENDITURE:—

Salaries :—Manager	...	per month at G.	350	
Assistant	...	" "	125	
Visiting Agent	...	" "	100	
Book-keeper	...	" "	25	
				G. 7,200
Tools	...	...	...	" 120
Stable and Cattle	...	...	...	" 500
Contingencies	...	...	...	" 2,000
Native Festivities	...	...	...	" 200
Coolie Brokerage	...	...	...	" 250
New Lines	...	...	...	" 1,000
House for Manager	...	...	...	" 4,000
Office and Stationery	" 300
Medical	" 100
Roads and Bridges	" 1,000

Carried forward ... G. 16,670

PARA RUBBER.

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JAVA RUBBER PLANTING.—*Contd.*

Brought forward ...	G. 16,670
CLEARING 250 BOUWS RUBBER:—	
Nurseries including purchase 150,000 Rubber seed at G. 15 per 1,000 and Transport on same ...	G. 5,000
Felling and Clearing at G. 25 per Bouw ...	„ 6,250
Draining ... „ 10 „ ...	„ 2,500
Lining ... „ 2 „ ...	„ 500
Holing ... „ 4 „ ...	„ 1,000
Planting ... „ 3 „ ...	„ 750
Roads ... „ 2 „ ...	„ 500
Fencing ... „ 5 „ ...	„ 1,250
Weeding 6 Months ... „ 12 „ ...	„ 3,000
Digging Allangs ... „ 10 „ ...	„ 2,500
Pests ... „ 1 „ ...	„ 250
Extras ... „ 1 „ ...	„ 250
	<u>G. 40,420</u>

SECOND YEAR.

CLEARING 250 BOUWS AND UP-KEEP OF EXISTING 250 BOUWS.

GENERAL EXPENDITURE:—

Salaries:—Manager ...	per month	at G. 400	
1st. Assistant ...	„	„ 150	
2nd. Assistant ...	„	„ 125	
Visiting Agent...	„	„ 100	
Book-keeper ...	„	„ 50	
		<u></u>	G. 9,900
Tools ...	...	...	G. 100
Contingencies ...	...	...	„ 2,000
Stable ...	...	...	„ 300
Coolie Brokerage ...	...	...	„ 200
New Bungalow (Assistant's)	...	...	„ 500
New Lines ...	...	...	„ 1,000
Up-keep Bungalows ...	...	...	„ 250
Up-keep Lines ...	...	...	„ 300
Up-keep Roads ...	...	...	„ 100
Native Festivities ...	...	...	„ 300
Stationery and Medical ...	...	...	„ 500
New Roads and Bridges ...	...	...	„ 1,000
		<u></u>	G. 16,450

NEW CLEARING:—

250 Bouws at G. 95 per Bouw (for details see first year) G. 23,750

UP-KEEP 250 BOUWS:—

Roads Repairs at G. 0.50 per bouw ...	G. 125
Weeding „ 21.00 „ ...	„ 5,250
Up-keep Drains „ 2.00 „ ...	„ 500
Supplying „ 0.50 „ ...	„ 125
Pest, &c. „ 1.00 „ ...	„ 250
	<u>G. 6,250</u>
	<u>G. 46,450</u>

JAVA RUBBER PLANTING.—*Contd.*

THIRD YEAR.

CLEARING 250 BOUWS AND UP-KEEP OF EXISTING 500 BOUWS.

GENERAL EXPENDITURE:—

Salaries:—Manager	...	per month at G.	450	
1st Assistant	...	"	"	150
2nd Assistant	...	"	"	125
Visiting Agent	...	"	"	100
Book-keeper	...	"	"	50
				<hr/>
				G. 10,500
Tools	...			" 100
Contingencies	...			" 2,000
Stable	...			" 300
Coolie Brokerage	...			" 200
New Bungalow	...			" 500
New Lines	...			" 1000
Up-keep Bungalows	...			" 250
Up-keep Lines	...			" 300
Up-keep Roads	...			" 100
Native Festivities	...			" 300
Stationery and Medical	...			" 500
New Roads and Bridges	...			" 1,000
				<hr/>
				G. 17,050

NEW CLEARING:—

250 Bouws at G. 95 per Bouw ... G. 23,750

Up-keep 500 Bouws:—

250 Bouws at G. 18 per Bouw	= G. 4,500	
250 " 25 " "	= " 6,250	" 10,750
		<hr/>
		G. 51,550

FOURTH YEAR.

CLEARING 250 BOUWS AND UP-KEEP OF EXISTING 750 BOUWS.

GENERAL EXPENDITURE:—

Salaries:—Manager	...	per month at G.	500	
1st Assistant	...	"	"	150
2nd Assistant	...	"	"	125
Visiting Agent	...	"	"	100
Book-keeper	...	"	"	50
				<hr/>
				G. 11,100
Tools	...			" 100
Contingencies	...			" 2,000
Stable	...			" 300
Coolie Brokerage	...			" 200
New Lines	...			" 1,000
Up-keep Bungalow	...			" 250
Up-keep Lines	...			" 300
Up-keep Roads	...			" 100
Native Festivities	...			" 300
Stationery & Medical	...			" 500
New Roads & Bridges	...			" 1,000
				<hr/>
				G. 17,150

NEW CLEARING:—

250 Bouws at G. 95 per Bouw	...	G. 23,750
Carried forward	...	G. 40,900

JAVA RUBBER PLANTING.—*Contd.*

				Brought forward	...	G.	40,900
Up-keep 750 Bouws :—							
250	Bouws at G.	15	per Bouw	...	G.	3,750	
250	"	18	"	...	"	1,500	
250	"	25	"	...	"	6,250	
						G.	14,500
						"	55,400

FIFTH YEAR.

Up-keep 1,000 Bouws :—							
250	Bouws at G.	10	per Bouw	...	G.	2,500	
250	"	15	"	...	"	3,750	
250	"	18	"	...	"	4,500	
250	"	25	"	...	"	6,250	
						G.	17,000
General Expenditure						"	18,000
						G.	35,000

SIXTH YEAR.

Up-keep 1,000 Bouws :—							
500	Bouws at G.	10	per Bouw	...	G.	5,000	
250	"	15	"	...	"	3,750	
250	"	18	"	...	"	4,500	
						G.	13,250
General Expenditure						"	18,000
New Factory, Washing Machine etc.						"	4,000
Tools (new)						"	1,000
Harvesting* 37,500 lbs. Rubber at G. 0.50						"	18,750
						G.	55,000

* 250 Bouws 300 trees—75,000 trees at $\frac{1}{2}$ lb. 37,500 lbs.

SEVENTH YEAR.

Up-keep 1,000 Bouws :—							
750	Bouws at G.	10	per Bouw	...	G.	7,500	
250	"	15	"	...	"	3,750	
General Expenditure						"	18,000
Repairs Factory etc.						"	250
Harvesting *84,375 lbs. Rubber at 0.50						"	42,188
						G.	71,688

*250 Bouws by 250 trees = 62,500 trees at $\frac{3}{4}$ = 46,875 lbs.
 250 " 300 " 75,000 " $\frac{1}{2}$ = 37,500 "
 84,375 lbs.

EIGHTH YEAR.

Up-keep 1,000 Bouws at G. 10 per Bouw							
General Expenditure						"	18,000
New Tools						"	500
Harvesting *134,375 lbs. Rubber at G. 0.50						"	67,188
						G.	95,688

*250 Bouws by 200 trees = 50,000 trees at 1 = 50,000 lbs.
 250 " 250 " 62,500 " $\frac{3}{4}$ = 46,875 "
 250 " 300 " 75,000 " $\frac{1}{2}$ = 37,500 "
 134,375 lbs.

JAVA RUBBER PLANTING.—*Contd.*

NINTH YEAR.

Up-keep 1,000 Bouws at G. 10	...	G. 10,000
General Expenditure	...	„ 18,000
Harvesting *200,000 lbs. Rubber at G. 0.50	...	„ 100,000
		<hr/> G. 128,000 <hr/>

*250 Bouws by 175 trees — 43,750 trees at $1\frac{1}{2}$	= 65,625 lbs.
250 „ 200 „ 50,000 „ 1	= 50,000 „
250 „ 250 „ 62,500 „ $\frac{3}{4}$	= 46,875 „
250 „ 300 „ 75,000 „ $\frac{1}{2}$	= 37,500 „
	<hr/> 200,000 lbs. <hr/>

TENTH YEAR.

Up-keep 1,000 Bouws at G. 10	...	G. 10,000
General Expenditure	...	„ 18,000
Tools (new)	...	„ 500
Harvesting *250,000 lbs. Rubber at G. 0.50	...	„ 125,000
		<hr/> G. 153,500 <hr/>

*250 Bouws by 175 trees = 43,750 trees at G. 2	= 87,500 lbs.
250 „ 175 „ 43,750 „ $1\frac{1}{2}$	= 65,625 „
250 „ 200 „ 50,000 „ 1	= 50,000 „
250 „ 250 „ 62,500 „ $\frac{3}{4}$	= 46,875 „
	<hr/> 250,000 lbs. <hr/>

RECEIPTS.

6TH YEAR	...	37,500 lbs. at 3s. nett per lb. = £. 5,625	...	= 67,500
7TH YEAR	...	84,375 „ „ „ „	12,656	... = 151,872
8TH YEAR	...	134,375 „ „ „ „	20,156	... = 241,872
9TH YEAR	...	200,000 „ „ „ „	29,999	... = 359,988
10TH YEAR	...	250,000 „ „ „ „	37,499	... = 449,988

SUMMARY.

YEARS.	EXPENDITURE.	RECEIPTS.	CAPITAL REQUIRED.	PROFITS.
1st	G. 40,420	...	G. 40,420	...
2nd	„ 46,450	...	„ 46,450	...
3rd	„ 51,550	...	„ 51,550	...
4th	„ 55,400	...	„ 55,400	...
5th	„ 35,000	...	„ 35,000	...
6th	„ 55,000	G. 67,500	...	G. 12,500
7th	„ 71,688	„ 151,872	...	„ 80,184
8th	„ 95,688	„ 241,872	...	„ 146,184
9th	„ 128,000	„ 359,988	...	„ 231,988
10th	„ 153,500	„ 449,988	...	„ 296,488
	<hr/> G. 732,696 <hr/>	<hr/> G. 1,271,220 <hr/>	<hr/> G. 228,820 <hr/>	<hr/> G. 767,344 <hr/>

(Signed) NOEL BINGLEY.

Tji Wangio Estate, March, 1907.

The following very conservative Estimate of the yield of Rubber and the cost of maintaining Para Rubber Plantation in West Java has been kindly supplied by Mr. A. H. Berkhout, late Conservator of Forests, Java.:-

ESTABLISHMENT AND MAINTENANCE OF A PARA RUBBER PLANTATION IN WEST-JAVA.

	1st year.	2nd year.	3rd year.	4th year.	5th year.	6th year.	7th year.	8th year.	9th year.	10th yr.	11th yr.	12th yr.
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
Purchase of the concession for say 1,000 acres @ Rs. 40 per acre	40,000	—	—	—	—	—	—	—	—	—	—	—
Felling, Clearing and Planting, say 300 acres in the 1st year	18,000	—	—	—	—	—	—	—	—	—	—	—
2nd year	—	24,000	—	—	—	—	—	—	—	—	—	—
3rd year	—	—	18,000	—	—	—	—	—	—	—	—	—
Roads and Bridges	1,000	1,000	1,000	—	600	600	600	600	600	600	600	600
Nurseries, including cost of Seeds and Stumps	10,000	2,500	—	—	—	—	—	—	—	—	—	—
Runggalows & Coolie Lines	1,300	2,600	—	—	—	—	—	—	—	—	—	—
Weeding	—	13,500	1,300	33,000	30,000	600	600	600	600	600	600	600
Tools and Implements	600	400	400	400	400	400	400	400	400	400	400	400
Manager and Conductors	6,000	7,000	7,000	7,000	8,000	8,000	8,000	8,000	9,000	9,000	9,000	9,000
Superintendent	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Fence	1,200	1,200	1,200	—	—	—	—	—	—	—	—	—
Contingencies	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
Quit Rent	—	—	—	—	—	—	—	—	—	—	—	—
Tax	—	—	—	—	—	—	—	—	—	—	—	—
Total Outlay	80,800	51,900	54,100	44,300	42,300	43,000	38,000	33,000	34,000	34,000	36,000	36,000
Cost of Tapping, Curing, Packing and Transportation of the Rubber at 0.75 Rs. per lb.	—	—	—	—	—	—	—	—	—	—	—	—
Revenue @ 1½ Rs. per lb.	—	—	—	—	—	—	—	—	—	—	—	—
Surplus	80,800	51,900	54,100	44,300	42,300	43,000	38,000	33,000	34,000	34,000	36,000	36,000

Rs. 1374,125.

	6th year	7th	8th	9th	10th	11th	12th
Yield per acre in the 6th year	45 lb.	80 "	110 "	150 "	200 "	200 "	200 "
Yield of the Plantation in the 6th year	13,500 lb.	42,000 "	78,500 "	113,000 "	153,000 "	185,000 "	200,000 "

Rs. -312,775.

Yield of the Plantation in the 6th year

7th	13,500	58,875	84,750	114,750	149,750	180,750	200,750
8th	—	—	—	—	—	—	—
9th	—	—	—	—	—	—	—
10th	—	—	—	—	—	—	—
11th	—	—	—	—	—	—	—
12th	—	—	—	—	—	—	—

The Estimated Expenditure is very high according to Mr. Berkhout's own admission.

ESTIMATE OF COST IN SOUTHERN INDIA.

ESTIMATE FOR OPENING 300 ACRES IN PARA RUBBER, WITH
6 YEARS EXPENDITURE.

This has been framed as an average result of opening in various districts and at elevations varying from sea-level to 3,000 feet, with rainfalls from 45 to 135 ins., pay 3 as. to 6 as. (18 to 36 cents) and other conditions differing almost as much. I do not include steep land, as I do not recommend such being opened, consequently though rates for roads and drains may appear low.

PURCHASE OF LAND is presumably from private owners. The British Government shows no disposition to throw open suitable land; Travancore and Cochin have of late refused many applicants, and the Mysore Government, though it has agreed to a conference on the subject in August, and may possibly grant applications, does not possess land at those low elevations which are recognised as most desirable. Still there is a good deal available, varying from rather over 2,000 to 3,500 in Mysore and the Wynaad, in Government and private hands, which, if carefully selected, will grow rubber. On the plains suitable land can be got from native owners, but great care must be taken with the titles.

FELLING AND CLEARING varies from Rs. 10 per acre in an ordinary hill district to Rs. 30 for the enormous evergreen forest on the Anamalai Hills. Rs. 15 suffices for good forest at foot of the ghauts.

NURSERIES.—If these were put down in the previous year actual cost would be say as follows:—

	Rs.
100,000 seed at Rs. 7·8 as. per 1,000 delivered	750
Making Nursery and Fencing	350
Upkeep	450
	Rs. 1,550

but this would involve commencing operations in July at least, instead of with felling in December,—and cost of superintendence, lines, etc., in the meantime. I do not include cost of baskets, as the plants would not go into the field before end of May following, and they do better in beds meanwhile, whilst, if they are in baskets, the roots have got far beyond the decaying remnants before May. Germinated seed in baskets may be used for planting and often does fairly, and seed at stake, 2 or 3 in a pit, is at times very successful, but, so far, I am in favour of plants from the previous year's seed, stumped; these cost Rs. 37 per 1,000, delivered on estate, if purchased in Ceylon at Rs. 20 per 1,000. The price in India follows that of Ceylon, plus delivery charges and a percentage for the plants being more on the spot and consequently more likely to come on well.

TAPPING should start in the 5th year, and, after six years the estate should maintain itself. No estimate is made for factory and machinery, these are left to be paid for out of receipts.

	Rs.
1. Purchase of land at Rs. 40 per acre, 300 acres	12,000
2. Felling and Clearing at Rs. 15 per acre	4,500
3. Nurseries, 60,000 plants at Rs. 37 per 1,000	2,220
4. Roads and Drains at Rs. 3 per acre	900
5. Lining and Pegs 16½' × 16½' less roads and stumps=150 plants per acre at Re. 1 per acre	300
6. Pitting 2' × 2' at Rs. 2·8 as. per acre	750
7. Filling pits and planting at Re. 1·8 as. per acre	450

PARA RUBBER.

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ESTIMATE OF COST IN SOUTHERN INDIA—*Contd.*

					Rs.
8.	Supplying	"	4 as,	...	75
9.	Shading	" Rs.	4	...	1,200
10.	Weeding	" "	12	...	3,600
11.	Fencing	" "	5	...	1,500
12.	Buildings--				
	Lines ...	...		Rs.	600
	Bungalow and Furniture	...		2,000	
13.	Tools ...	...		...	2,600
14.	Management—Superintendent	at Rs.	250	3,000	500
	Writer	" "	50	600	
	Tappal & Coolies	" "	21	252	
15.	Sundries—Advances	...		500	
	Medicines, Books, Stationery, etc.	...		500	
	Taxes	...		300	
	Contingencies	...		153	
					1,453
1st Year's	Expenditure brought forward				35,900
2nd Year	Weeding	...		3,600	
	Supplies	...		200	
	Management	...		2,400	
	General Upkeep, Taxes, etc.	...		1,300	
3rd Year	Weeding	...		3,600	
	Supplies	...		100	
	Management	...		1,500	
	General Upkeep, etc.	...		1,000	
4th Year	Weeding	...		3,000	
	Management	...		1,500	
	General Upkeep, etc.	...		1,000	
5th Year	Weeding	...		3,000	
	Management	...		2,000	
	General Upkeep, etc.	...		1,000	
6th Year	Weeding	...		2,700	
	Management	...		2,000	
	General Upkeep, etc.	...		1,000	
					5,700
					Rs. 66,800

E. G. WINDLE.

July 31st, 1906.

PARA RUBBER IN BRITISH NORTH BORNEO.

The following information, affecting the costs of planting rubber estates in Borneo, was given in the "India Rubber Journal" of January 14th, 1907 :—

British North Borneo is divided geographically and ethnologically into four portions:—The East Coast, comprising all land from Cowie Harbour on the South to Paitan Bay on the North, and extending inland as far as

PARA RUBBER IN BRITISH NORTH BORNEO—*Contd.*

the sources of the Segama, Kinabatangan, Labuk, and Sugut rivers; the Kudat district comprising all land from Telaga to Sampanmangaio Point; the West Coast, from Sampanmangaio Point to Mengalong and extending as far inland as Sungai Rayoh; and lastly the interior, from Sungai Rayoh to Tambunan on the North, Tomani on the South, and Labau on the East.

Practically all estate labour on the East Coast is imported indentured labour, the men being brought from Singapore, and costing landed in Borneo \$65 per head for Chinese, and \$75 per head for Javanese and other Malays; of these sums \$30 and \$48 respectively is recoverable from the coolie, leaving the balance to be looked upon as wages; the Chinese contract is for one year and the Javanese for two years.

Work on a rubber estate should prove congenial to them, and they will probably form the chief labour force of all rubber estates opened in the Kudat district.

The following are about the rates now being paid for contract work on rubber estates at Beaufort :—

Jungle felling \$3 to \$6 per acre.

Jungle felling, lopping, stacking and burning clean \$10 to \$13 per acre. If holing be also included \$14 to \$15 per acre for all above.

In the interior there are two estates, Sapong Estate, the property of the Sapong Rubber and Tobacco Estates, Ltd., and Melalap Estate, owned by the Manchester North Borneo Rubber Co., Ltd.

The cost of agricultural operations varies very little all over B. N. Borneo, and the following may be taken as the most usual, and are in a very few cases exceeded :—

Jungle felling \$3 per acre.

Jungle felling, lopping, stacking and burning clean \$12 per acre.

Holing 1½ ft. by 1½ feet by 2ft. deep, one cent per hole (\$2 per acre of 200 holes.)

Hoeing \$5 per acre.

Draining, ten cubic feet, one cent.

On locally engaged Dusuns and Bajaus or Kadyans the brokerage only amounts to \$5 per head for men signing on for one year or more.

The soil of British North Borneo equals, if it does not actually surpass, that of the Federated Malay States, and is about much the same as that of Sumatra. The above prices of various work are as cheap as anywhere east of Ceylon, and the climate has also shown itself well suited to Para rubber, judging by the growth in such widely different spots as Sandakan and the interior.

The writer has since received the following letter from an authority well-versed on labour in Borneo :—

"My own opinion is that £20 an acre will cover the costs in connection with the planting and upkeep to the end of the fifth year. In the case of the Langkon North Borneo Rubber Company the cost of felling and clearing 600 acres and planting 462 acres with rubber was £4,406."

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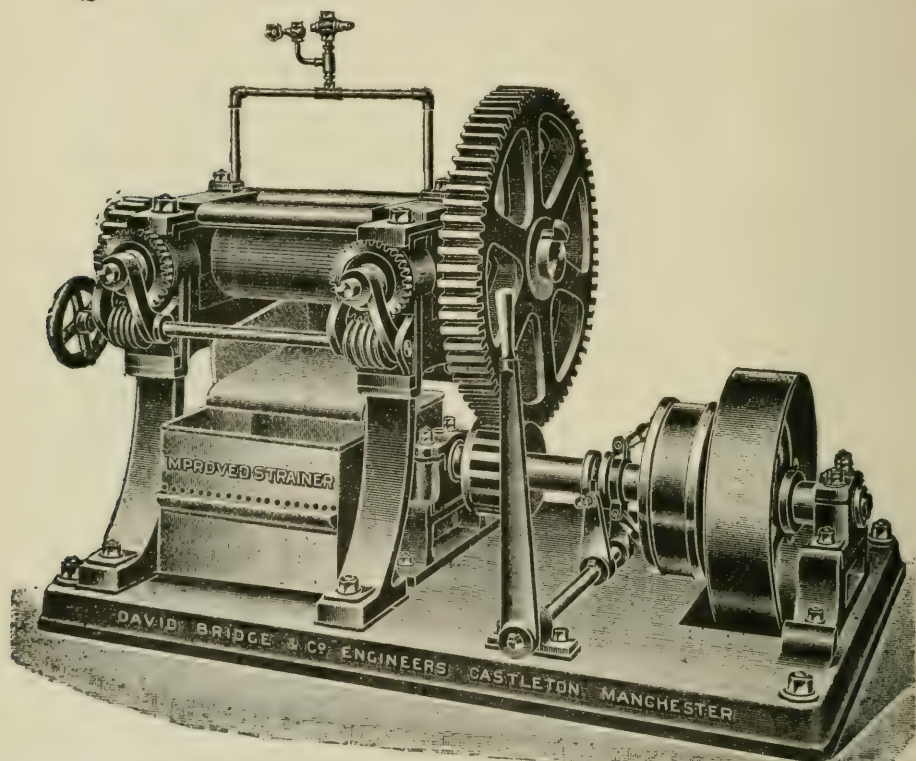
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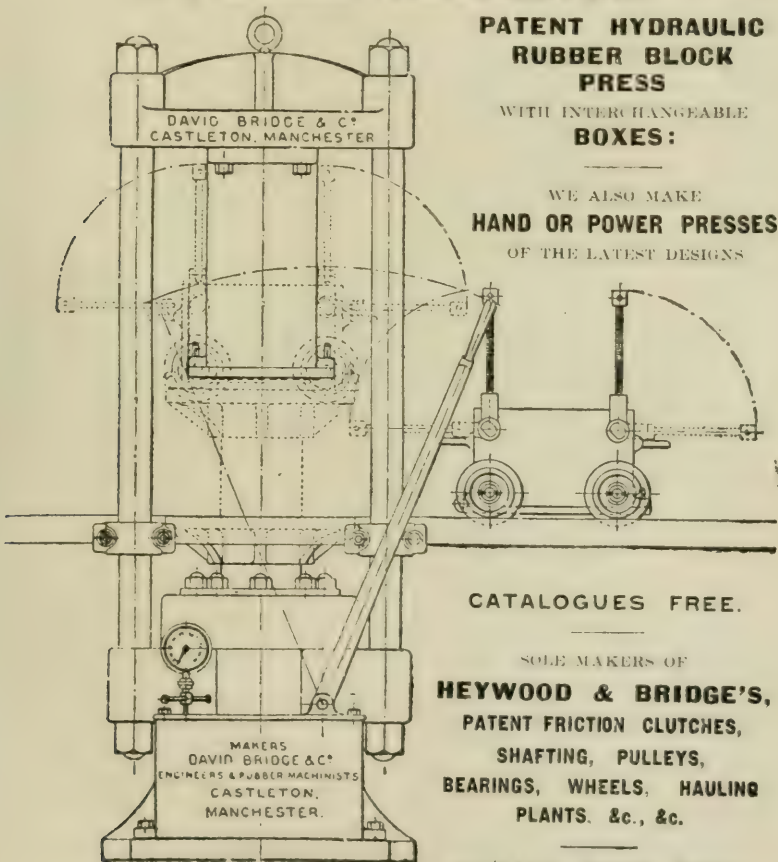
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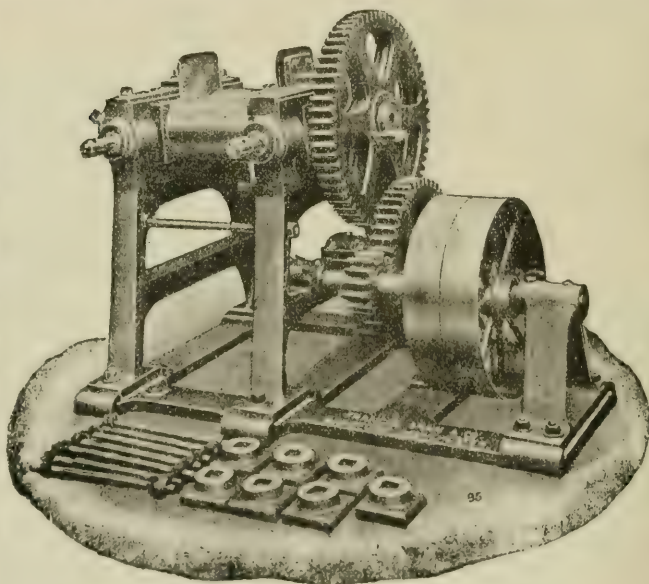
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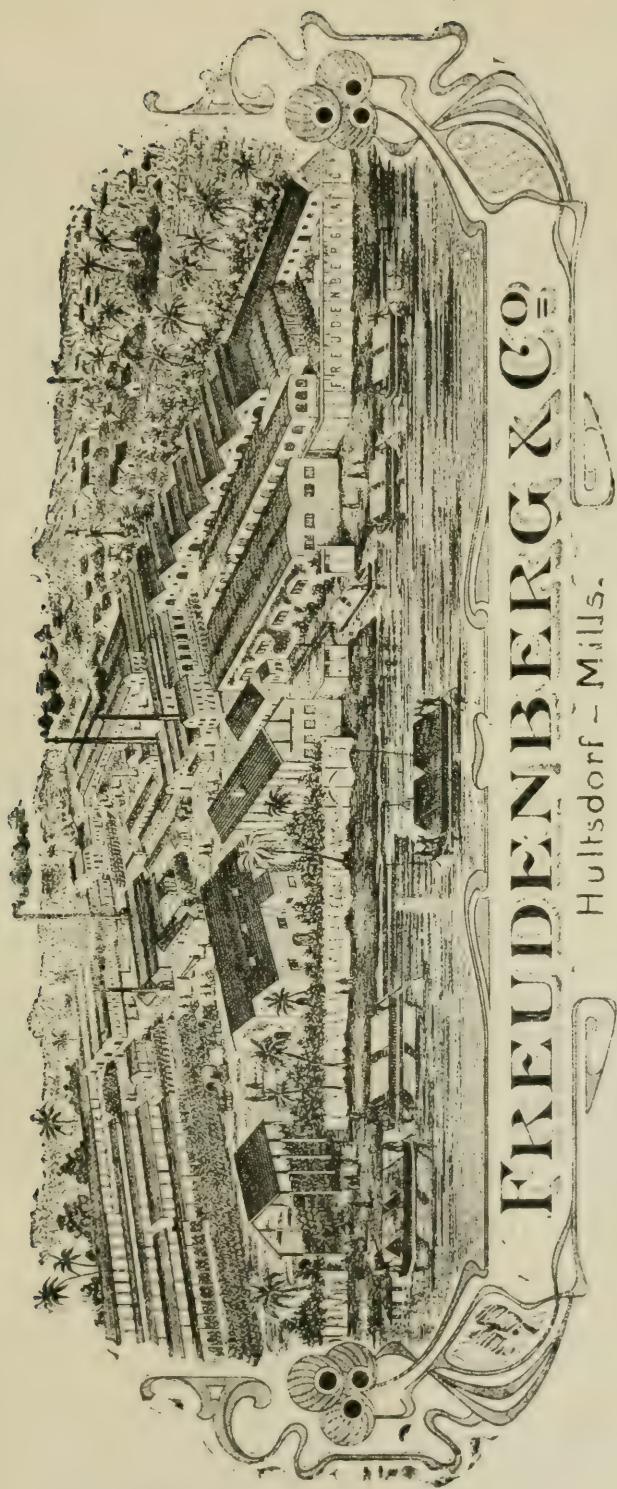
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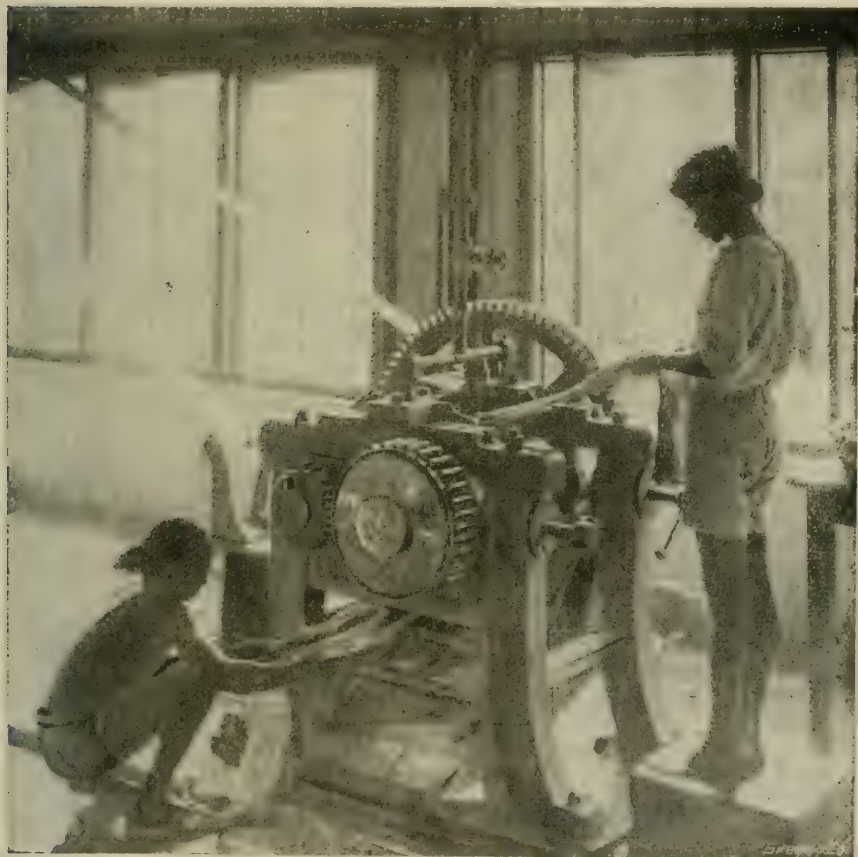
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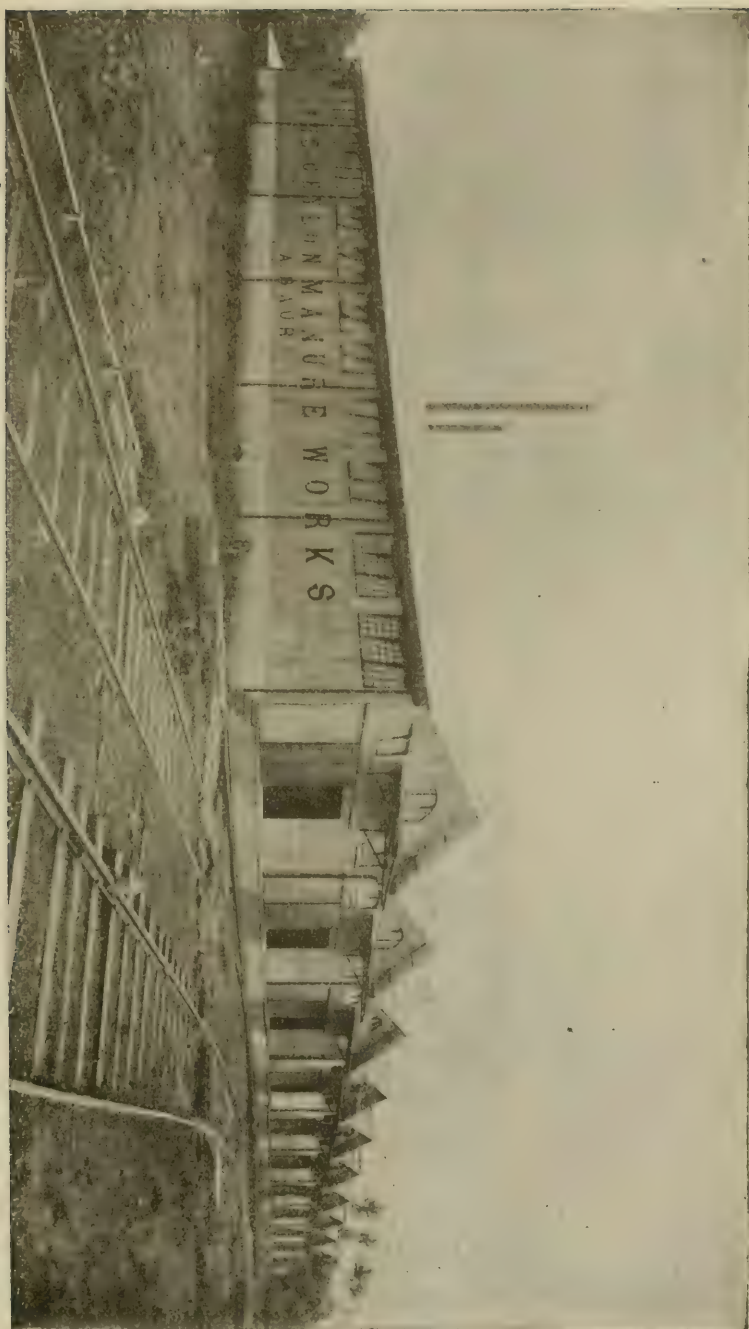
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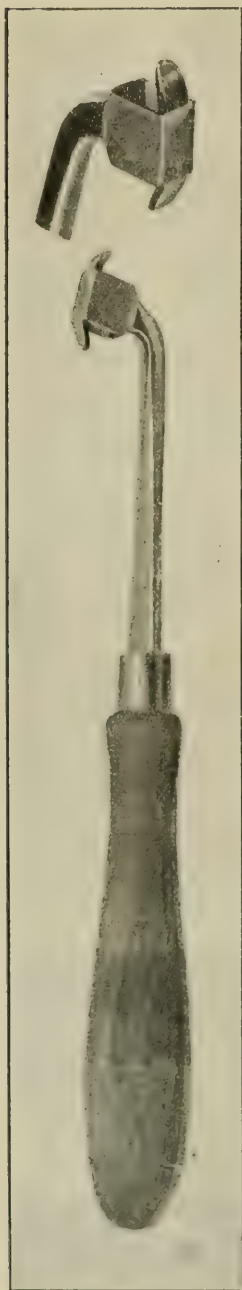
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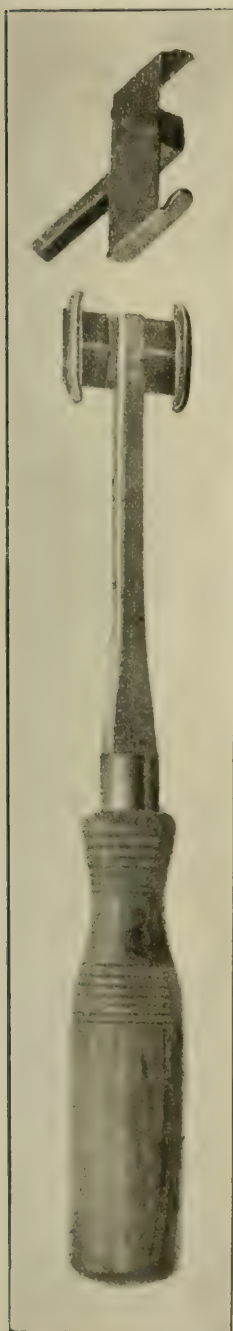
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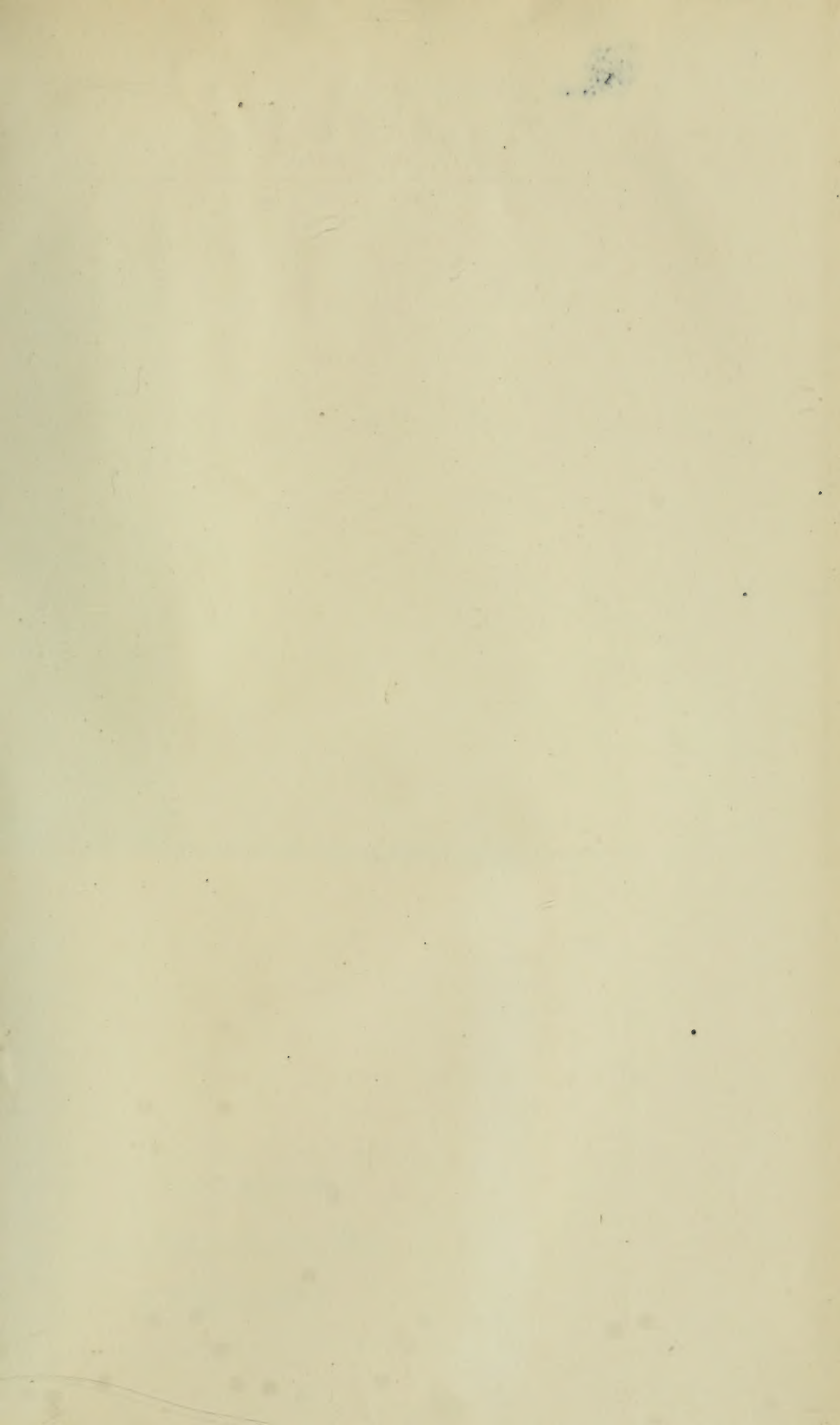
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